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APR 30 1924

ENGINEERING:

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See advertisement page 8.
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AUTOMATIC FEED REGULATORS.
And Auxiliary Machinery as supplied to the Admiralty. 2179

Dredging Plant
OF ALL DESCRIPTIONS.
FLOATING CRANES. COAL BUNKERING VESSELS.

Werf Conrad, HAARLEM, HOLLAND.
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See half-page Advert. last week and next week. 2087

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GEORGE RUSSELL & CO., LTD., Motherwell. 1867

STEEL TANKS, PIPES, GASHOLDERS, &c.
Thos. Piggott & Co., Limited,
BIRMINGHAM. 1241
See Advertisement last week, page 19.

Spencer-Hopwood & Kirke
PATENT BOILERS *See Page* 71. 1994
Sole Makers: SPENCER-BONECOURT, LTD., Parliament Mansions, Victoria St., London, S.W.

Tank Locomotives.
Specification and Workmanship equal to Main Line Locomotives.
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SPECIAL MACHINERY, try
THOMAS HUNT & SONS,
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SALE AND VALUATION
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PLANT AND MACHINERY
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Tubes and Fittings.
Sole Licensees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes. 817
The Scottish Tube Co., Ltd.,
HEAD OFFICE: 34, Robertson Street, Glasgow.
See Advertisement, page 81, April 11.

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PASSENGER AND CARGO STEAMERS.
SHALLOW DRAFT VESSELS. 1553

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Gear Cutting.
Worm Wheels cut up to 13 ft. diam.
Bevel and Mitre Wheels planed up to 3 ft. diam.
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OIL FUEL APPLIANCES,
Systems
PRESSURE, AIR, STEAM
For Boilers of all types.
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Naval Outfits a Speciality,
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designed and constructed by
MANNING, WARDLE AND COMPANY, LIMITED,
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GEAR WHEELS up to 10 ft. diameter.
FLY ROPE and SPUR DRIVING WHEELS up to 26 ft. diameter.
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Spiral, Worm and Worm Wheels.
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Gas Engines Inspected, Tested and Reported upon. Over 25 years' experience. Tel.: Maryland 1736 & 1737. Wire: "Rapidising, London." —Great Eastern Road, Stratford, E.15. 1794

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MECHANICAL ENGINEERS,
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Undertake SPECIAL MACHINE WORK of any description.
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LATHE WORK up to 10 ft. diameter.
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GENERAL CONSTRUCTIONAL ENGINEERS,
Boilers, Tanks, & Mooring Buoys
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IRON & STEEL
Tubes AND Fittings
AND
Steel Plates.
STEWARTS AND LLOYDS, Ltd.
GLASGOW BIRMINGHAM - LONDON.
See Advertisement, page 56. 1872

Peter Brotherhood Ltd.,
PETERBOROUGH.
STEAM ENGINES AND TURBINES.
GAS AND OIL ENGINES.
AIR COMPRESSORS.
REFRIGERATING PLANT. 1475
See Advertisement, page 53, April 11.

The Glasgow Railway Engineering Company,
GOVAN, GLASGOW. LTD.,
London Office—12, Victoria Street, S.W.
MANUFACTURERS OF
RAILWAY CARRIAGE, WAGON & TRAMWAY WHEELS & AXLES.
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Direct Current.

Two	26 Kw.	105 Volts.	"Howden-B.E.E.
Two	52 ,,	,, ,,	"Brotherhood-Laurence Scots."
Two	100 ,,	440/500 ,,	Gerrett Semi-Portable.
One	120 ,,	110 ,,	"Belliss-Siemens."
One	150 ,,	220 ,,	"Howden-Lane, Dynamo."
Two	200 ,,	,, ,,	"W. H. ALLEN."
Two	200 ,,	,, ,,	"Belliss-Siemens."
One	240 ,,	440/500 ,,	"Belliss-Phœnix Dynamo."
One	375 ,,	250 ,,	"Allen-Westinghouse."
One	400 ,,	240 ,,	"Howden-Siemens."
One	500 ,,	230 ,,	"Howden-B.T.H."
One	500 ,,	230 ,,	"Belliss-B.T.H."
One	500 ,,	500 ,,	Metropolitan Vickers Turbo.
One	600 ,,	500 ,,	"Belliss-Mather & Platt."
One	750 ,,	220 ,,	"Parsons-Crompton" Geared Turbo.
One	1250 ,,	250 ,,	"Belliss" Turbo.

Alternating Current, 3-Phase, 50 Periods.

One	400 Kw.	500/550 Volts.	"Howden-G.E.C."
One	750 ,,	,, ,,	"Metropolitan Vickers."
One	850 ,,	,, ,,	"Fraser & Chalmers."
Two	1000 ,,	,, ,,	"Metropolitan-Vickers."
One	1000 ,,	3300 ,,	"B.T.H."
Two	1000 ,,	,, ,,	"Metropolitan-Vickers."
One	2000 ,,	500/550 ,,	,, ,,
One	3000 ,,	6600 ,,	"B.T.H."

All above are modern, and condensing plant is available in nearly all cases.
We can also offer several Suction Gas and Diesel Sets, Babcock Boilers up to 30,000 lbs. per hour, and a very large number of motors, generators, Motor-generators, rotary converters, etc.
Enquiries Invited
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PATENTS. DESIGNS. TRADE MARKS.

EXAMINATION AND PHOTOGRAPHY OF METALS. See F. DAVIDSON & Co's. Advt., page 17. 2114

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ENGINEERS, IRLAM, MANCHESTER.
FEED WATER HEATERS,
CALORIFIERS, EVAPORATORS,
CONDENSERS, AIR HEATERS,
Merrill's Patent TWIN STRAINERS for Pump Suctions.
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SYPHONIA STEAM TRAPS, REDUCING VALVES.
High-class GUNMETAL STEAM FITTINGS.
WATER SOFTENING and FILTERING. 3739

YARROW & CO. (1922), LTD., GLASGOW.
LAND AND MARINE
YARROW BOILERS. 1553

Matthew Paul & Co., Ltd.
LEVENFORD WORKS, **Dumbarton.** 1483
See Full Page Advt., page 61, March 28.

Forgings.
Walter Somers, Limited,
HALESOWEN. 7116

Taylor & Challen Presses
For Production of SHEET METAL WORK, COINAGE, CARTRIDGES AND GUNPOWDER.
Foundry, Works, and Showrooms: BIRMINGHAM.
See advert., page 59, March 28. 8195

Head, Wrightson & Co.,
LIMITED.
See Advertisement page 59. 2402

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T. SUMMERSON & SONS, LIMITED, DARLINGTON. 2006

RAILWAY AND TRAMWAY ROLLING STOCK.
Hurst, Nelson & Co., Ltd.,
THE GLASGOW ROLLING STOCK AND PLANT WORKS, MOTHERWELL. Od 3382

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Windsor House, Westminster, S.W.1. 1675
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Electric Cranes.
Traversers.
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Reddish. 1357

Centrifugals.
Pott, Cassels & Williamson,
MOTHERWELL, SCOTLAND. 1676
See half-page Advertisement, page 70, April 11.

The Manchester Steam Users' ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.

Chief Engineer: O. E. STROMEYER, M.I.C.E.

Founded 1854 by Sir WILLIAM FAIRBAIRN.

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Principal: J. W. WILSON, M.I.C.E., M.I.Mech.E. Vice-Principal: MAURICE WILSON, A.M.I.C.E. The 154th session will commence on April 29th. D 513

Busk Studentship in AERONAUTICS.

This Studentship, founded in memory of E. T. BUSK, open to British subjects of British decent, and of value of about £150, is to be awarded shortly.

Forms of application and conditions of appointment may be obtained from PROF. B. M. JONES, Engineering Laboratory, Cambridge. D 527

Correspondence Courses for Inst.Civil Engrs., Inst.Mech.E., London Univ. (Matric., Inter., B.Sc.), and All ENGINEERING EXAMINATIONS personally conducted by Mr. TREVOR W. PHILLIPS, B.Sc. (Honours), Assoc. M.Inst.C.E., M.R.S.I., F.R.S.A., etc. Also Day Tuition in Office. Excellent results at all Exams. Courses may commence at any time, and all Students receive individual tuition.—For full particulars apply to 8/11, TRAFFORD CHAMBERS, 58, SOUTH JOHN STREET, LIVERPOOL. 1993

Engineering Salesmanship and SALES MANAGEMENT.—Write for brochure describing our special Course of Training for posts of unlimited scope in this lucrative field.—DIRECTOR, Institute of Engineering Salesmanship, 333, Oxford Road, Manchester. 2108

TENDERS.

THE CARNARVON CORPORATION invite

Tenders for New Roller and PATHS, &c., for their Swing Bridge at Carnarvon.

Apply for specifications to BOROUGH SURVEYOR. Carnarvon. D 498

FIRE ENGINE & ESCAPE.

THE BANGOR (CO. DOWN) URBAN DISTRICT COUNCIL invite

Tenders for the Supply of a 60/70 H.P. MOTOR FIRE ENGINE, with detachable 50 ft. two-wheel Fire Escape, complete with solid tyres.

The Fire Engine to be equipped with a pump capable of delivering 350/400 gallons per minute at 100 lbs. pressure. The carrying capacity to be for at least Ten men.

Tenders will be received by me up to Twelve Noon on Tuesday, 29th April, 1924.

J. MILLIKEN, Clerk to the Council.

Town Hall, Bangor, Co. Down. 11th April, 1924. D 511

METROPOLITAN WATER BOARD.

SUPPLY AND ERECTION OF FENCING—SHOOTERS HILL PUMPING STATION, KENT.

The Metropolitan Water Board invite

Tenders for the Supply and ERECTION of approximately 1000 yards WROUGHT IRON FENCING, at their Shooters Hill Works in the Kent District.

Forms of Tender, Specifications and Drawings giving full particulars may be obtained from the Chief Engineer, Metropolitan Water Board, New River Head, 173, Rosebery Avenue, E.C.1, by personal application (Room 155), or upon forwarding a stamped addressed brief envelope.

Tenders must be on the official forms, enclosed in sealed envelopes, and addressed to "The Clerk of the Board, Metropolitan Water Board, New River Head, 173, Rosebery Avenue, E.C.1," endorsed "Tender for Fencing, Shooters Hill," and delivered at the offices of the Board not later than 11 a.m. on Tuesday, 29th April, 1924.

The Board do not bind themselves to accept the lowest or any Tender.

G. F. STRINGER, Clerk of the Board.

Offices of the Board, New River Head, 173, Rosebery Avenue, E.C.1. 12th April, 1924. D 509

METROPOLITAN WATER BOARD.

SUPPLY OF LATHES, &c., FOR BOARD'S TESTING SHOP, ROSOMAN STREET, CLERKENWELL, E.C.1.

The Metropolitan Water Board invite

Tenders for the Supply of LATHES, and other MACHINE TOOLS, for their Testing Shop, Rosoman St., Clerkenwell, E.C.1.

Forms of Tender and Specification giving full particulars may be obtained from the Chief Engineer, Metropolitan Water Board, New River Head, 173, Rosebery Avenue, E.C. 1, by personal application (Room 155) or upon forwarding a stamped addressed brief envelope.

Tenders must be on the official forms enclosed in sealed envelopes, and addressed to "The Clerk of the Board, Metropolitan Water Board, New River Head, 173, Rosebery Avenue, E.C.1," endorsed "Tender for Lathes, etc." and delivered at the offices of the Board not later than eleven a.m. on Wednesday, 30th April, 1924.

The Board do not bind themselves to accept the lowest or any Tender.

G. F. STRINGER, Clerk of the Board.

Offices of the Board, New River Head, 173, Rosebery Avenue, E.C.1. 12th April, 1924. D 510

The Director-General, India Store Department, Branch No. 16, Belvedere Road, Lambeth, S.E.1, REQUIRES BEARING PLATES FOR RAILS.

Tenders due on the 6th May, 1924. Tender forms obtainable from above. D 530

BENGAL-NAGPUR RAILWAY COMPANY LIMITED.

The Directors are prepared to receive

Tenders for:—

MILD STEEL RIVETS (FOR VERY EARLY DELIVERY).

Specification and Form of Tender can be obtained at the Company's Offices, 133, Gresham House, Old Broad Street, E.C.2, on or after 14th April, 1924.

A fee of 10s. will be charged for the Specification, which is NOT RETURNABLE.

Tenders must be submitted not later than Noon on Tuesday, 29th April, 1924.

The Directors do not bind themselves to accept the lowest or any Tender, and reserve to themselves the right of reducing or dividing the order.

By Order of the Board. R. C. VOLKERS, Secretary. D 516

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED, are prepared to receive

Tenders for the Supply of:—

1. ROLLED STEEL DISC WHEELS & AXLES FOR CARRIAGES & WAGONS and STEEL AXLES FOR WAGONS.
2. STEEL TYRES FOR CARRIAGES AND WAGONS.
3. STEEL DRAWBARS FOR WAGONS.

Specifications and Forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W.1.

Tenders, addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked:—"Tender for Wheels & Axles," or as the case may be, must be left with the undersigned not later than Twelve Noon on Friday, the 2nd May, 1924.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of 10s. for each copy of each Specification.

Copies of the drawings may be obtained at the Offices of Messrs. ROBERT WHITE & PARTNERS, Consulting Engineers to the Company, 3, Victoria Street, Westminster, S.W.1.

A. MUIRHEAD, Managing Director.

91, Petty France, S.W.1. 12th April, 1924. D 515

ABERDEEN CORPORATION WATER WORKS.

EXTENSIONS 1920.

CONTRACT No. 18—PIPING.

The Town Council of Aberdeen are prepared to receive

Tenders from Competent

Persons willing to enter into a Contract for the MANUFACTURE and DELIVERY of about 5503 lineal yards of 30 in., 24 in., 16 in. and 13 in. diameter PIPES and SPECIALS, of the following alternative types, viz.:—

(A) Cast Iron.
(B) Mild Steel (Lapwelded).

The Drawings may be inspected and Specification, Schedule of Quantities, and Form of Tender obtained, on and after 11th April, 1924, on application at the Water Engineer's Office, 41½, Union Street, Aberdeen. Early application is desirable and no specimation will be given out after 21st April.

For each Specification a deposit of Five Pounds Sterling will be required, which sum will, after a Tender has been accepted, be returned to the Tenderer provided that he shall have sent in a *bona fide* Tender, based on the drawings, specification and schedule of quantities provided, with the schedule of quantities fully priced out in detail, and shall not have withdrawn the same.

The employment of labour shall be in accordance with the conditions of the Unemployment Grants Committee.

Tenders on the Forms prescribed and enclosed in securely sealed envelopes, endorsed "Tender for PIPING" are to be addressed to the undersigned. No Tender delivered after Noon on 28th April, 1924, will be considered.

The Town Council do not bind themselves to accept the lowest or any Tender.

GEORGE MITCHELL, M.Inst.C.E., F.G.S., Water Engineer.

Water Engineer's Office, 41½, Union Street, Aberdeen. 7th April, 1924. D 475

APPOINTMENTS OPEN.

Works Manager Wanted for Heavy Engineering Works in the Midlands. Age between THIRTY and FORTY.—Address, stating qualifications and salary, D 518, Offices of ENGINEERING.

Rate Fixer and Demonstrator REQUIRED, for Machining Department of Midlands Firm of Steel Forging Manufacturers specialising in Crankshafts. Essential qualifications include expert knowledge of machining times and ability as a practical demonstrator from actual experience of above class of work.—Address, D 480, Offices of ENGINEERING.

Traveller Wanted by Firm of Old-established Machine Tool Makers making heavy tools as used by Shipbuilders, etc. Applicants must be experienced in this class of work, and to the right man a Directorship may be acquired. State age, Experience and Salary, in confidence.—Address, D 523 Offices of ENGINEERING.

Managing Clerk With Knowledge of costs and book-keeping, REQUIRED for up-to-date engineering concern in Birmingham district.—Address, stating age and salary required, D 526, Offices of ENGINEERING.

The Royal Air Force REQUIRES ELECTRICIANS, ELECTRICAL FITTERS, POWER STATION TRADESMEN and WIRELESS OPERATORS. Age limits 19 to 30. Pay from 24/6d. to 34/6d per week, on enlistment, and all found. Allowance for wife and children to men 26 and over.—Write, stating age, or call, INSPECTOR OF RECRUITING, R.A.F., 4, Henrietta Street, Covent Garden, London, W.C.2. D 385

SINGAPORE, STRAITS SETTLEMENTS.

WATER DEPARTMENT.

ASSISTANT SUPERINTENDENT OF WATER MAINS AND SERVICES.

The Municipal Commissioners of Singapore require an

Assistant Superintendent of Mains and Services in the Water Department, age about 25 to 30, unmarried, on a three years' Agreement with possible extension. Preference will be given, other things being equal, to Ex-service men. Applicants must be "Registered Plumbers," with experience in the work of a mains and services department under a water authority in the United Kingdom, and must be accustomed to carrying out the model by-laws and regulations. They should be accustomed to controlling men, and experience in a workshop and in training men will be an advantage. A bonus of $50 will be given on the selected candidate's passing successfully an examination in colloquial Malay within twelve months of his arrival in Singapore. Salary $4560 for the first, $5040 for the second, and $5520 for the third year, paid monthly in dollars, the currency of the Colony, the value of the dollar being two shillings and fourpence sterling. If re-engaged, the candidate, in his fourth year would probably be placed in class 6 of the salary scheme, in which the annual increments are $40 per month and the maximum salary $540 per month. The pay of the appointment for the first year at the above rate would be about £532. Such local transport allowance as may from time to time be sanctioned by the Commissioners will be paid. Free passage will be provided, with half-pay during the voyage out. The selected candidate must pass a medical examination. Applications, stating whether married or single, age and place of birth, and giving details of education, apprenticeship, training, and experience generally, with war service, and referring to all the above requirements in detail accompanied by copies (only) of testimonials, and also personal references, are to be lodged with Messrs. C. C. LINDSAY & PEIRCE, M.M.Inst.C.E., 180, Hope Street, Glasgow, Agents for the Commissions (who will give further particulars if requested), not later than Tuesday, 22nd April. D 467

Pulverised Fuel.—Engineer REQUIRED to act as Travelling Representative for Pulverised Fuel Apparatus of British Manufacture. Thorough knowledge of combustion problems and of boiler management is essential, also experience of negotiations with power and fuel users.—Address, D 536, Offices of ENGINEERING.

Mechanical Draughtsman, Experienced, at weekly rate of £3 9s. 11d. which includes Civil Service Bonus (at present 2s/11 REQUIRED immediately. Applicants must be over 21 years.—Apply, by letter, to the COMMANDANT, Experimental Station, Porton, Near Salisbury. D 514

Draughtsman Wanted by a Firm in the Midlands accustomed to designing Steel Structures, Coal Screening and Sorting Plants. Must be well up in stresses and strains.—Address, stating age, experience, salary required and when at liberty, D 506, Offices of ENGINEERING.

Draughtsman, Tramway and Railway Rolling Stock.—Apply (letter only), stating age, experience and salary to The CAR MANAGER, The ENGLISH ELECTRIC Co., Ltd., Box 36, Preston, Lancs. D 503

Draughtsman Required.—Experienced in Bus Body Design. State age, experience and salary required to—BRUSH ELECTRICAL ENGINEERING CO., LTD., Falcon Works, Loughborough. D 501

First-class Draughtsman WANTED. Experienced in design and application of Roller Bearings, light and heavy duty. State age, experience and salary.—Address, D 502, Offices of ENGINEERING.

Several Capable Draughtsmen WANTED preferably with experience in designing light mechanical motions or automatic machinery.—State age, experience and salary to BOX 714, Advertising Offices, 84, Queen Victoria Street, London, E.C.4. D 457

Draughtsman Wanted by Firm in the Midlands manufacturing Municipal Vehicles. Applicants should state age, experience and salary required and enclose copies of references.—Address, D 473, Offices of ENGINEERING.

Mechanical and General ENGINEERING DRAUGHTSMAN REQUIRED to prepare detail drawings and schemes in Drawing Office of large manufacturing works in the Midlands. The following training is essential:—

At least two years' day student in recognised College or University, College diploma or engineering degree, and three years in workshop of well-known firm of general engineers; at least three years' drawing office experience.—Address in confidence, stating age, training, experience, salary required and when at liberty, D 436, Offices of ENGINEERING.

Senior Draughtsman Required by Aircraft Manufacturers near London.—Address, stating experience, age, and salary required, D 519, Offices of ENGINEERING.

Wanted, First-class Draughtsman for the North of England, with experience in the design of machinery for stone crushing, screening and cement making and the layout of complete plants.—Address, stating details of experience, age and salary expected, D 445, Offices of ENGINEERING.

SITUATIONS WANTED.

Engineer, M.I.Mar.E. (35), REQUIRES POSITION ashore. 14 years' Sea-going, 6 years Chief Engineer. Knowledge of ship repairing, Marine Salvage, book-keeping, erecting Sheep Shearing and Hydraulic Presses for Wool, speaks Spanish thoroughly, also some Italian, French, and Portuguese. First-class references.—Address, D 468, Offices of ENGINEERING.

Engineer, A.M.I.M.E., A.M.I.A.E., British, Ex-Service, Married, 34, Desires Position of responsibility, outdoors, with scope. Good Draughtsman, Organiser. Would control Transport or accept post as Representative. Minimum Salary £300 yearly. Yorkshire district.—Address, D 407, Offices of ENGINEERING.

Foreman, Boilermaking and Structural Work, SEEKS POSITION as Manager or Foreman. Age 37. Thorough practical knowledge Manufacturing and Erection, Tank, Gas Plant, Blast Furnace, and Structural Work. 13 years Foreman and Assistant Manager.—Address, D 492, Offices of ENGINEERING.

WORK WANTED.

J. Kirkaldy, Limited. WORKS: 1933 BURNT MILL, ESSEX.

We are organised to produce castings from 2 lbs. to 2 tons. Cast-iron, Semi-steel, and Non-ferrous castings. Coils of every description. Steel and Copper. Sheet Metal Work. Over 40 years' experience is at your service. Send your enquiries along.

Haighs (Oldham) Limited, GLOBE IRONWORKS, OLDHAM.

SOLICIT ENQUIRIES for WORK of any description. Suitable for fully equipped PATTERN SHOP, FOUNDRY and MACHINE SHOPS. Large or small jobs or quantities undertaken.

KEEN PRICES QUOTED—QUICK DELIVERIES.

GIVE US A TRIAL!!

Telephone 1273, Oldham. Telegrams Haigh, Oldham.

London Office: 117-119, City Road, E.C.1. D 499

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THE FRENCH TORPEDO-BOAT "ENSEIGNE GABOLDE."

SINCE the signing of the Washington Treaty for the limitation of naval armaments, which deals mainly with capital ships, and fixes both their total tonnage and the tonnage of each unit, interest centres largely in the smaller classes of warships, such as light cruisers, destroyers, torpedo boats and submarines; it centres also at the same time in the shipbuilding companies, who for many years past have made a speciality of these important, although smaller, vessels. The British firms of repute in this class of naval construction and examples of their work are well known to our readers. The Augustin Normand Company, of Havre, are not only reckoned as being amongst the foremost French concerns for the construction of lighter warship units, but they also hold the distinction of being probably the oldest-established shipbuilding firm in the world. The company are able to date back to the seventeenth century, when, in 1627, an ancestor of the Normand family built in a yard he owned at Honfleur, on the Seine estuary, opposite Havre, a sailing ship which took part in the siege of La Rochelle. Since that early date, the Normands have succeeded each other in the business. They built, in the early years of their activity, a large number of sailing craft which did good duty in their time.

The yard was transferred in 1816 to Havre by a descendant of the founder, Augustin Normand, whose name is intimately connected with the transformations which ship construction underwent during the first half of last century, namely, the adoption of steam propulsion and the substitution of iron for wood in the building of the hull. Augustin Normand commenced the construction of steam-propelled ships in 1829, the first one being a mail-packet for the French State, followed by a tug-boat, the Neptune, of 295 tons displacement and 150-h.p. The construction of other steam-propelled ships rapidly followed; among these may be mentioned the Hambourg, built in the 'thirties of last century, which frequently covered the distance between Havre and Hamburg in 50 hours; also the Phénix, of 628 tons displacement, and 160-h.p., which crossed to London from Havre in 16 hours, and the Etoile No. 2, of 115 tons, whose speed, a notable one for the period, was 11·5 knots. The pioneer among screw-propelled vessels, the Napoléon, afterwards re-named the Corse, was launched in the Normand yard on December 6, 1842. The name of one of the sons of Augustin Normand, Benjamin Normand, is intimately connected with the adoption of compound and triple-expansion engines on board ship. Compound engines were fitted in 1860 in the Furet, and these reduced the steam consumption by half, whilst a triple-expansion engine he built in 1871 also met with complete success.

Commencing with the year 1877, the Augustin Normand shipbuilding firm, which was then under the direction of Jacques Augustin Normand, devoted the greater part of their activity to the building of torpedo boats and destroyers. Their first torpedo boats had a displacement of 30 tons; they were propelled by 500-h.p. engines running at 350 revolutions, supplied with steam from boilers of the locomotive type. These early boats had a speed of over 19 knots. Since that date, the firm have built boats of this type in large numbers, both for the French Navy and the navies of other nations. The original type of the French destroyer was designed by Messrs. Normand, and was represented by the Durandal and Hallebarde, which entered into the service in 1899. These boats had a displacement of 280 tons, and were propelled by two triple-expansion engines developing together 5,300-h.p., supplied with steam from two Normand boilers. Their speed was over 27 knots, well above the contract speed, as was the case also with the torpedo boats. Normand destroyers have also been built both for the French Navy and for foreign navies. In the year 1904, the Normand yard built the first French turbine-driven torpedo boat, this being the boat No. 293; it had a displacement of 95 tons, was equipped with Parsons' turbines, supplied with steam from Normand boilers, and had a speed of 26·2 knots. Their turbine-driven destroyer Bouclier, built in 1911, had a speed of over 35 knots, whereas the contract speed was 31 knots only. The Normand boiler, and, for large powers, the Normand-Sigaudy boiler, are specialties of the firm.

During the war, the company were actively engaged in the manufacture of projectiles, but this fact did not prevent their dealing with the construction of patrol boats, submarine chasers, and other craft, also with the transformation of submarine boats. They also repaired a number of ships of various classes and built the gun mountings on others. The company further manufactured on a large scale apparatus for the protection of ships against floating mines, and material for the French Corps of Engineers.

The Normand Company commenced the construction of marine Diesel engines in 1908, since when they have built several boats propelled by these engines. At the present time their activity is particularly directed to the construction of submarine boats; they own a special type of mine-laying submarine vessel. They also manufacture stationary Diesel engines.

We illustrate in the view Fig. 1 on the present page, Figs. 2 to 4, on Plate XXXIII, and in Figs. 5 to 18 on pages 484, 485 and 486, the sea-going torpedo boat Enseigne Gabolde, recently built by them for the French Navy. Messrs. Normand were awarded the contract for this boat in October, 1913, but its final completion was repeatedly delayed by other classes of urgent work carried out by the firm during the war, and it has only recently been handed over to the French naval authoritiesafter a series of satisfactory trials.

The principal dimensions of the boat are as follows:—

Length between perpendiculars	82·076 m. =	269 ft. 3 in.
Length overall	82·600 m. =	272 ft. 0 in.
Breadth at water-line... ...	8·210 m. =	27 ft. 0 in.
Mean draught	2·620 m. =	8 ft. 7 in.
Depth of hold amidships ...	5·100 m. =	16 ft. 8 in.
Displacement with normal load	905·110 tons.	
Power developed for 31 knots	20,000 S.H.P.	

The hull framing is built of particularly strong scantlings. The middle-line keelson runs from the frame 23 to the collision bulkhead; it is of continuous construction throughout the engine-room between the frames 31 and 56, and also throughout the double-bottom which forms oil-fuel storage compartments, between the frames 56 and 94. Longitudinals are built in the wings, there being two throughout the engine-room compartments, three throughout the stokeholds, and one fore and aft. Another horizontal longitudinal forms amidships an extension of the fore and aft hold platform stringer-plates. The transverse water-tight bulkheads are 11 in number; that No. 1 forward extends up to the forecastle, whilst the others extend up to the main deck.

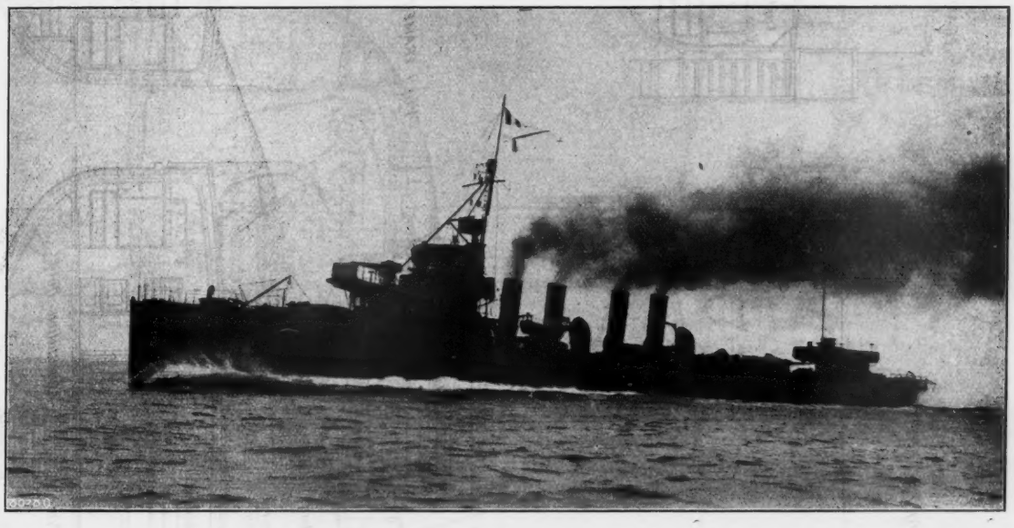


FIG. 1. THE VESSEL STEAMING AT 33·45 KNOTS.

The officers' quarters, aft of the engine-room, consist of a cabin, a ward-room and a lavatory for the commanding officer; five cabins for the other officers, a ward-room, two pantries and junior officers' mess. The quarters for the petty officers are aft of the officers' quarters and contain a cabin for the chief petty officer, on the port side in the mates' station, where are located the cabins for the latter. The crew's quarters are forward, in two compartments; an upper one under the forecastle on the main deck, 18 m. (59 ft.) in length and having 2·1 m. (6 ft. 10 in.) available headroom; the lower one is on the hold platform, 2·4 m. (7 ft. 10 in.) in height in the centre between the deck beams. Hammock-berths are provided for 45 men in the upper compartment and for 27 in the lower one.

The armament consists of three 100 mm. (3·937 in.) guns and one 75-mm. (2·953 in.) anti-aircraft gun. There are, further, four 550-mm. (21·654 in.) torpedo-launching tubes mounted in pairs on circular platforms on deck.

The propelling machinery consists of two independent sets of geared Parsons' turbines, each set being in a separate engine-room. The high-pressure and the low-pressure turbines of each set are geared

THE FRENCH TORPEDO BOAT "ENSEIGNE GABOLDE."

CONSTRUCTED BY THE CHANTIERS ET ATELIERS AUGUSTIN NORMAND, SHIPBUILDERS AND ENGINEERS, HAVRE.

Fig. 5. FRAME 3.

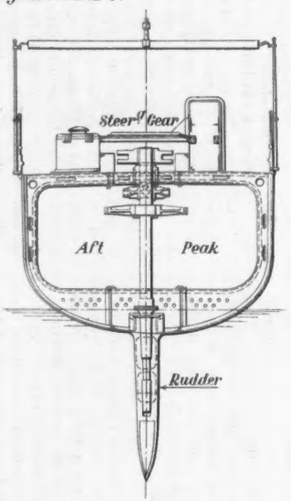


Fig. 6. FRAME 10.

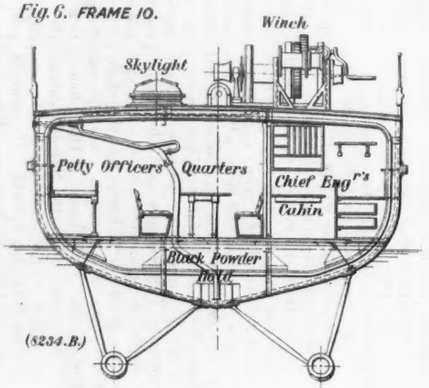


Fig. 7. FRAME 25.

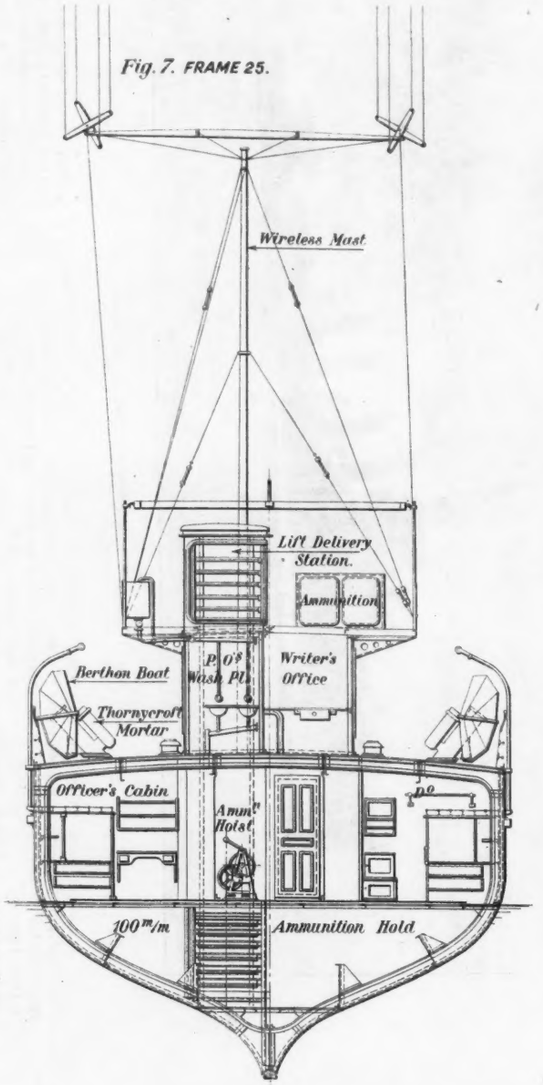


Fig. 8. FRAME 15.

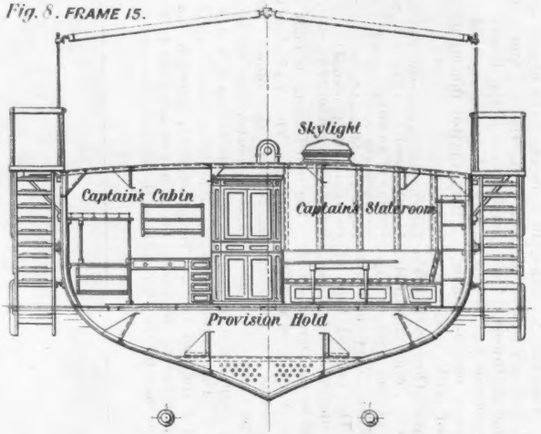
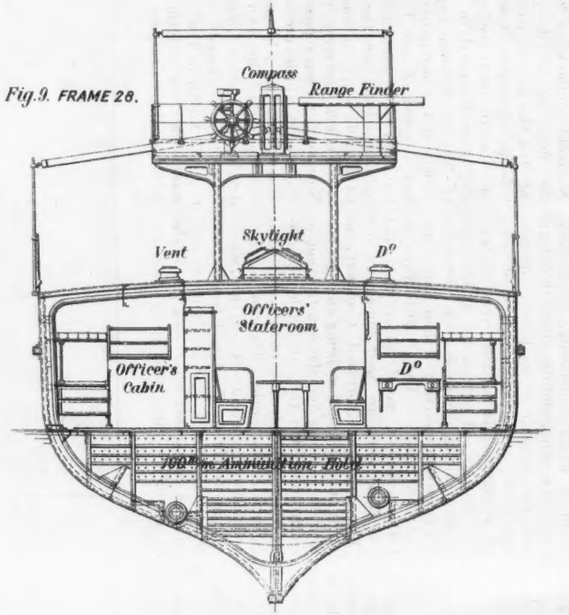


Fig. 9. FRAME 28.



THE FRENCH TORPEDO BOAT "ENSEIGNE GABOLDE."

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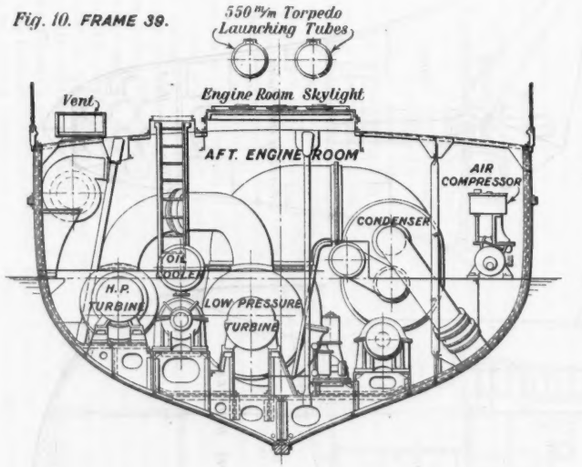
Fig. 10. FRAME 39.



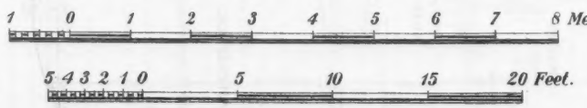


Fig. 11. FRAME 47.

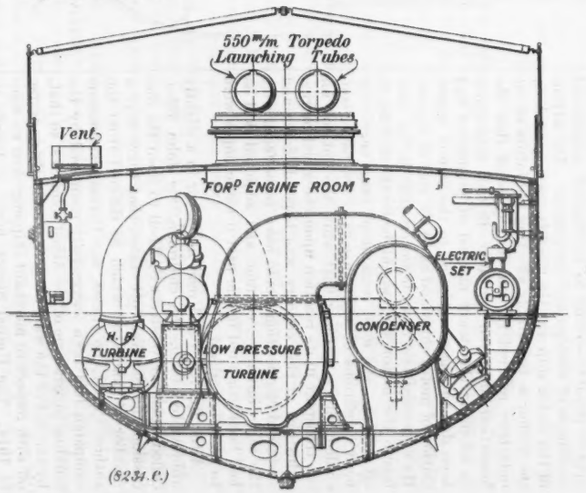


Fig. 12. FRAME 64.

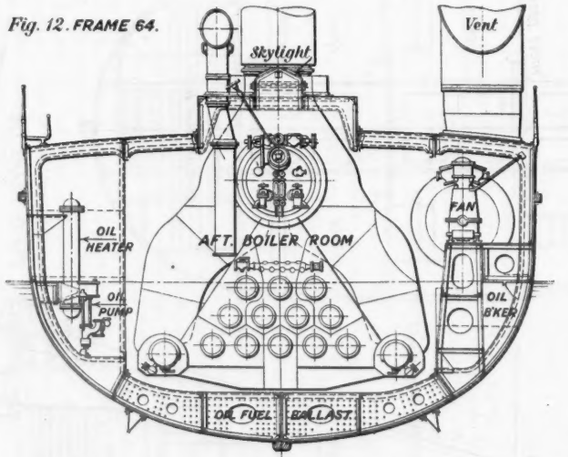


Fig. 13. FRAME 86.

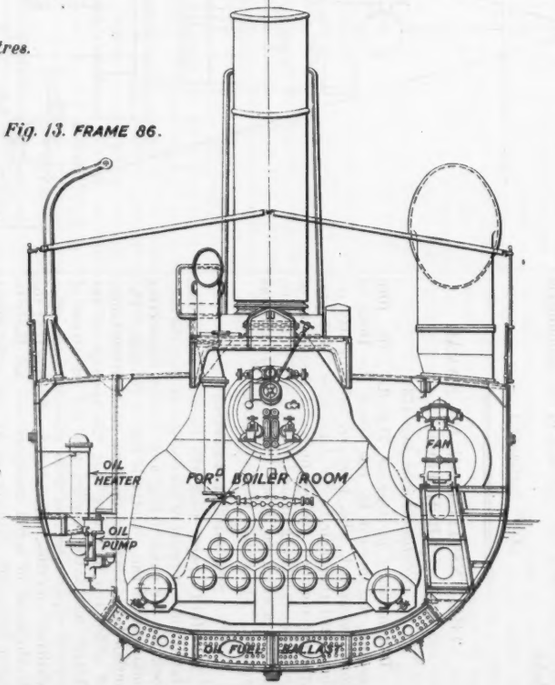


Fig. 14. FRAME 113.

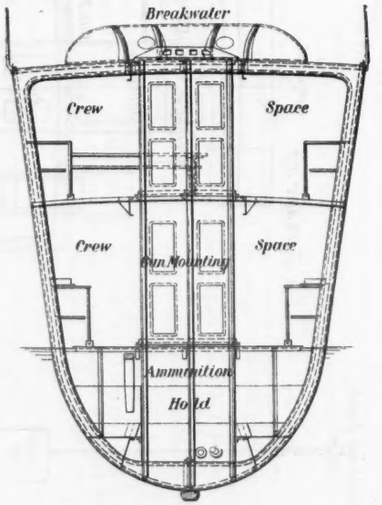
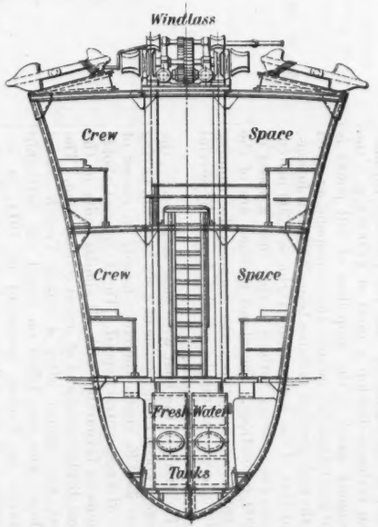


Fig. 15. FRAME 121.



to the spur wheel on the propeller shaft. The port shaft is, moreover, connected up for low speeds to a cruising turbine, which exhausts into the two high-pressure turbines. An astern turbine is provided in the casing of each low-pressure turbine. The turbines develop a total of 22,000-h.p.; the designed speed of the propellers at full power is 440 revolutions per minute, the corresponding speed of the high-pressure turbines being 2,500 revolutions, and that of the low-pressure turbines 1,500 revolutions, the cruising turbine having then a speed of 3,700 revolutions. The ahead turbines are of the Parsons reaction type; the turbines for running astern have one impulse wheel followed by several rows of Parsons blading.

The trials of the boat were most satisfactory, the average speed in the course of a six-hour run having been 33·436 knots, therefore largely in excess of the 31-knot contract speed. The Enseigne Gabolde compares favourably with all similar units of the same displacement and of recent construction. The boat was named after a young French Naval Officer who was killed on board the battleship Liberté, in Toulon roadstead in 1911, in recognition of his gallant conduct during the fire which preceded the explosion in the ammunition holds.

(To be continued.)

THE INSTITUTION OF NAVAL ARCHITECTS.

(Continued from page 473.)

THE morning meeting of Thursday, the 10th instant, was opened by His Grace the Duke of Northumberland, who, however, subsequently relinquished the chair to Sir John Biles. The programme included the reading and discussion of three papers relating to marine and aerial transport, the first of which was by Mr. Archibald Hurd and was entitled "The Future of Sea Transport."

SEA AND AIR TRANSPORT.

Mr. Hurd's paper took the form of a reasoned statement in support of his conclusion that the outlook for the shipbuilding and marine engineering industries of this country is full of promise. The author based his views on three main circumstances of which the first was that the tonnage of the British mercantile marine was not in excess of normal requirements as were those of some other maritime countries. His second point was that the development of aerial transport was not likely to injure mercantile shipping—as at first sight might appear possible—owing to the limited commercial usefulness of airships and aeroplanes. The advent of the motor ship was the third factor regarded by the author as favourably affecting the future of the industries referred to, and he suggested that the hesitation displayed by some British shipowners in adopting the newer method of propulsion had been due to uncertainties as to the rate of depreciation of motor ships and as to the cost of repairs. He expressed the view, however, that in the near future the motor ship would be established as, in all respects, the most economical cargo carrier for most conditions of sea transport. The paper concluded with a warning that while the outlook for sea transport in its reaction upon the allied marine industries of this country was hopeful, fierce and sustained competition would have to be faced with the same initiative, courage and acquired skill as had been exhibited in the past if those hopes were to be fully realised.

After Mr. Hurd had read his paper in a slightly abbreviated form, the chairman, Sir John Biles, called upon Sir Westcott S. Abell to open the discussion and Sir Westcott stated that there were a number of points on which he differed from the author. First, he stated, the German submarine campaign had been successfully countered by the building programme of the Allied countries, so that, by the end of the war, we were practically no worse off with respect to merchant shipping than we were in 1914. The United States, however, largely in response to representations of the other Allies, had continued her building programme longer than we did and this policy had resulted in the production of the surplus tonnage. With regard to the ton-for-ton policy referred to in the paper, the speaker pointed out that by the terms of the Peace Treaty Germany had been required to surrender merchant tonnage and to build no new tonnage for five years. If the latter condition had been duly enforced, the position would not be so bad as it was to-day. Aircraft, in the speaker's opinion, did not bear on the economic position at all, and with regard to motor ships he said that shipowners were not so much concerned with the question of depreciation as

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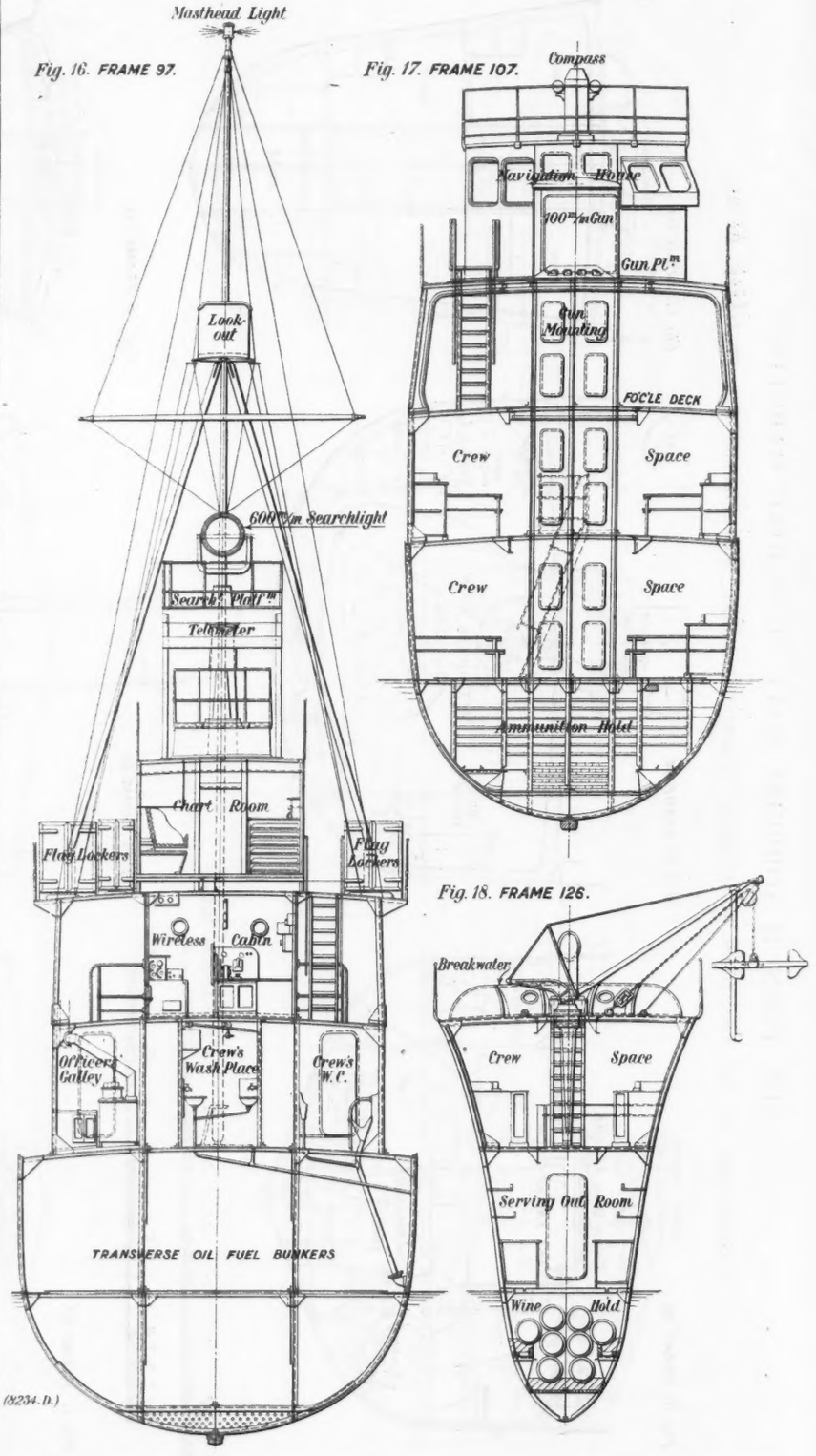

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they were with the matter of reliability in service. He thought, however, that it was now safe to say that the reliability of motor vessels had been more or less established to the satisfaction of shipowners.

Sir Archibald Denny, who followed, took exception to a statement in the paper to the effect that the Germans were foremost in all departments of physical research; he did not think they were equal to the French or British in that respect. In connection with the use of internal-combustion engines for marine propulsion the speaker mentioned that a bill was now passing through the United States House of Representatives to authorise the expenditure of some 25,000,000 dols. for replacing the steam-propelling machinery of some of their war-built merchant vessels by oil engines. He thought this sum would be sufficient for converting in this way all the vessels which were really worth converting. The speaker further pointed out, in connection with the use of oil engines, that shipowners were somewhat uneasy as to possible fluctuations in the price of fuel oil. If a steamer were converted to burn oil under boilers it was possible to fall back on coal firing if the price of oil rose too high, but with vessels fitted with internal-combustion engines this could not be done.

The next speaker, Mr. W. H. Whiting, said that while he hoped that the author's views were correct, he had not been convinced by the arguments put forward that the ships required in the future would be built in this country. Referring to the absence of surplus tonnage in the British mercantile marine in comparison with those of other countries, he remarked that a paper read by Sir Westcott Abell a year ago had given a comprehensive and exhaustive statement of facts relating to the world's shipbuilding, and an examination of the curves in that paper did not support the view that there was a vast superabundance of tonnage of merchant shipping. The speaker did not think that there was much more shipping in existence at the present time than there would have been if the war had not occurred. With regard to the limited sphere of usefulness of aeroplanes and airships, he thought the question turned not so much on speed as on the value of the cargo. Expensive transport methods could be used to convey valuable goods occupying a comparatively small space. In conclusion, the speaker remarked that hopes for the future of sea transport might be based upon two things, one of which was the general recovery of industry abroad, while the other was the fact that large masses of people congregated in one part of the world to which food had to be transported from other parts where it could be produced more cheaply.

At this point the chairman suggested that the two remaining papers should be read and the discussion on all three continued together subsequently. Commander C. D. Burney, before reading his paper on "The Development of the Airship with Special Reference to Transport," which formed the next item on the programme, said he wished to make a few remarks on Mr. Hurd's paper. It did not follow, he said, as stated by Mr. Hurd, that the sea must always carry the most powerful fighting machines. The sea would always carry the greater part of the world's commerce but not necessarily the means of protecting that commerce. He suggested also that the development of aerial transport in the future might modify the design of ships, since if the whole of that class of transport on which higher charges could be sustained were carried by air, there would be less inducement for ships to maintain high speeds. Furthermore, while airships could not transport great weights, it was possible that, on account of their much higher speed, a greater number of persons could be carried between two points in a given time by airship than by steamer and also at a lower cost. He did not think that the change which would be effected in sea transport as soon as air transport could be shown to be really reliable was fully realised.

Commander Burney's paper, which he then read in abstract, was intended to supplement Mr. Hurd's contribution by a brief description of the present position and future prospects of the airship. The author, in dealing with means of flotation, pointed out that the differences between water-borne and air-borne vessels were essentially quantitative rather than qualitative, but that the quantitative differences were sufficiently great to introduce immense difficulties in the production of a successful air-borne vessel. These would be appreciated when it was remembered that the displacement of 1,000 cub. ft. of sea water gave an upward lift of 28·5 tons, while the displacement of an equal volume of air produced a lift of only 66 lb. Referring to the use of helium in airships in place of hydrogen, the author pointed out that the lift from the former gas was 7 per cent. less than from the latter, which fact would reduce the potential earning capacity of airships of the size proposed for the Indian route by as much as 84,000*l.* per annum for a weekly service. Apart from this, the rarity and difficulty of separating helium from other gases rendered its use for commercial airships quite out of the question. Furthermore, the author emphasised in this connection, the fact that the source of fire in airships was petrol, and not hydrogen, pointing out that if a satisfactory engine employing heavy oil in place of petrol could be developed, airships, and other types of aircraft, could be rendered immune from the risk of fire. Discussing the form of the gas container, the author pointed out that this was determined by aerodynamical and not by structural considerations. As regards head resistance, the most successful streamline shape produced so far had a volumetric coefficient of 0·52 when applied to a commercial form of airship. The earning capacity of an airship, however, increased more rapidly with increase of volumetric efficiency for the same speed than did the cost of propulsion and appeared to reach a limiting value with a volumetric coefficient of about 0·62; this figure, the author stated, was that upon which the design of most modern airships was based.

In discussing the question of hull design, the author remarked that the rigid principle was the only practicable one for airships of the larger sizes. He stated that the distributed nature of the lifts and the concentrated character of the loads resulted in considerable static bending moments although the dynamic bending moments set up when manœuvring the airship at high speeds were of more importance. For ships of any given fineness ratio, the dynamic bending moments varied as the cube of the diameter and as the square of the speed. Moreover, they might be either positive or negative, and in the horizontal or vertical planes according to the position of the rudder and elevators which gave rise to the particular manœuvre. In spite of the complicated system of forces to which the members of the airship structure were subjected, the improvements made in the analysis of the forces and in the design of the structures to resist them were such that it was now possible to construct an airship in which the factors of safety under the worst possible loading conditions would not be less than four, without sacrificing in any way the lightness necessary for commercial efficiency.

In conclusion, the author gave some particulars of the airships it was proposed to employ in what is now known as the Burney airship scheme. The airships, he said, would have a displacement of 5,000,000 cub. ft., giving a gross lift of 150 tons, of which 75 tons would be available for lifting the fuel, crew, passengers and cargo. The power installation would comprise seven interchangeable units developing a maximum of 600 b.h.p. each and giving a cruising speed of 75 miles per hour. The maximum economical length of flight would be between 2,000 and 2,500 miles, and the proposed route between England and India would be covered in two portions, viz., London to Cairo (2,300 miles) and Cairo to Bombay (2,400 miles). Finally, a reference was made to the development of mobile airship bases which could be moved from place to place to enable alternative routes to be tried until those best adapted to the new means of transport were determined.

The third paper, entitled "Sea-Borne Coastal Trade," was next read by Sir Alfred Read. This was a brief communication, in which the author traced the development of coastal shipping, referring to the effects of competition by railways and motor road vehicles, and mentioning that one of the greatest difficulties with which this class of shipping had to contend at the present time arose from the tidal restrictions at the large docks. He pointed out that it was useless to contemplate building 15-knot boats for the coastwise trade if the time lost in port for various reasons reduced the working speed to 10 knots, and pleaded for the co-operation of harbour and port authorities in the provision of more suitable dock accommodation.

The first speaker in the resumed discussion was Commander J. C. Hunsaker, of the United States Navy, who remarked that all means of transport were at first unsafe and uncertain, airships being no exception in this respect. He did not agree that the elimination of petrol would completely overcome the risk of fire from hydrogen. Helium could now be produced at the cost of 5 cents per cubic foot, and he thought the cost of production would be reduced to about 1 cent per cubic foot in the future. If helium were used, a small petrol fire could be extinguished without much damage resulting, but this was not the case if hydrogen were employed for lifting purposes. The danger from lightning had also to be considered in connection with the use of hydrogen. With regard to the structural design of airships, the speaker stated that redundancy was not disadvantageous. Owing to this characteristic the stresses measured in flight in the case of the Shenandoah had proved to be less than the calculated values. Dynamic bending moments had also proved to be less than had been anticipated. In flight they were of the same order as the static bending moments, but were very much higher in the case of an airship moored to a mast in a gusty wind. After paying a tribute to the work of the late Mr. C. I. R. Campbell in the design of the airship R.38, he mentioned that the Germans had employed the type of transverse frame designed by Mr. Campbell, in the new airship they were now building for the United States Navy.

Commander Cave-Brown-Cave, continuing the discussion, remarked that the figures for fuel consumption given in Commander Burney's paper indicated that hydrogen would be used in the engines to secure fuel economy. An alternative method was to condense the exhaust gases and recover the water from them, and if this system were employed it would not be necessary to discharge hydrogen to compensate for the loss of the fuel consumed. The speaker thought the suggested alternative would be preferable from the commercial point of view, as hydrogen was an expensive fuel. Referring to the use of helium in airships, the speaker agreed that the risk of fire from petrol was enormously greater than that from hydrogen, and added that there was very little risk of an airship being struck by lightning while in flight. It was of the utmost importance that public opinion should not be built up on the necessity for helium, as, although Commander Hunsaker had given some encouraging figures as to the cost of producing the gas, it appeared that the only practical sources existed on the American continent, and this fact, of itself, constituted a serious handicap. In conclusion, the speaker referred to the importance of not minimising the difficulties connected with the development of large airships.

The next speaker, Mr. S. Payne, who said he had acted as assistant to the late Mr. C. I. R. Campbell, expressed gratitude to Commander Hunsaker for his appreciation of Mr. Campbell's work. The speaker added that, in addition to copying the girder construction of the R.38 in the new airship for the United States Navy, the Germans had also copied the position of the control car. He agreed with Commander Burney's statement that hydrogen could be produced cheaply, but said he could not regard the plant necessary for filling large airships as being easily portable. He was also unaware of any method of structural design that would eliminate lateral loading from the girders of an airship of from 700 ft. to 800 ft. in length, and added that if there were any such scheme he would be glad to have particulars of it. The question of dynamic loading had by no means been neglected in the design of the R.38, and every effort had been made to ascertain its magnitude. The speaker agreed with Commander Burney's view with regard to petrol as a source of fire in airships, and also with Commander Cave-Brown-Cave's remarks as to the minimising of possible dangers. It was quite possible, he said, to get a considerable accumulation of hydrogen in the corridor of an airship while rising,

and men had been partially overcome by the presence of the gas.

The last speaker in the discussion, Mr. G. H. Narbeth, referred to Mr. Hurd's paper, in which he said the author had alluded to the work of Lord Fisher in connection with the adoption of oil fuel in the Navy. In the speaker's opinion, the most important part of Lord Fisher's work in this connection was his insistence on the storage of adequate stocks of liquid fuel in this country. With regard to the development of internal-combustion engines for marine propulsion, the speaker remarked that authoritative figures as to running costs were required, and suggested that shipowners employing Diesel-engined ships should publish such figures. He thought that the maintenance costs would be found to be remarkably small. In connection with the supplies of liquid fuel the speaker referred to the possibilities of employing alcohol and enquired whether Commander Burney had taken this fuel into consideration. The production of hydrocarbons by treating coal with hydrogen at high temperatures and pressures, on which experiments had been carried out in Germany, was another matter of importance in connection with fuel supplies.

The Chairman's invitation to the members present to speak on Sir Alfred Read's paper met with no response, and Mr. Hurd was then called upon to reply to the speakers on his paper. Owing to the lateness of the hour, Mr. Hurd said he would reply in writing. He remarked, however, that if his references to the future of the shipbuilding industry were regarded as unduly optimistic, he was glad they erred on that side rather than on the other. The construction of motor-ships in this country, he added, would probably be speeded up by the progress made in other countries, and we should thus be compelled to lay down ships of that class. Commander Burney also said he would reply fully in writing, but he wished to make it clear that he fully appreciated the good work of Mr. Campbell in connection with the design of the R.38. In reply to Commander Cave-Brown-Cave's remarks as to the recovery of water from the exhaust gases of airship engines, he said his reason for proposing to use hydrogen was to extend the life of the engines, which was increased owing to the fact that hydrogen reduced the temperature of the explosions and also of the exhaust.

After a vote of thanks to the authors of the three papers had been proposed by the Chairman and duly carried, the meeting was adjourned.

Rolling and Drifting of Ships.

On Thursday afternoon the Duke of Northumberland presided, and at the opening of the meeting called upon Mr. M. P. Payne, R.C.N.C., to read his paper on "Results of Some Rolling Experiments on Ship Models." In this paper the tests were described, and the results given of an investigation into the rolling characteristics of bulged and unbulged vessels of the Royal Sovereign class. As originally built, these ships were not fitted with bulges, but had bilge keels, in consequence of which, combined with their moderate metacentric height, they proved excellent ships as regards rolling properties in a sea way. When the bulges were added, bilge keels were not fitted, and it was anticipated that the new underwater form would offer more resistance to rolling than the original naked form and thus in part compensate for the omission of the bilge keels. Although this was the case, it appeared that the decrease in rolling period, which accompanied an increased metacentric height of the bulged forms, associated as it was with a lower resistance to rolling than that of the unbulged forms fitted with bilge keels, caused them under certain conditions to roll to larger angles than was the case in the original form. A report of the Commander-in-Chief of the Atlantic Fleet gave the angle of maximum roll for two bulged ships as from 12½ degrees to 15 degrees each way, and of the unbulged ships under the same condition as about 8 degrees each way. The fitting of bilge keels to the bulged ships was therefore thought to be desirable, and recourse was had to model experiments to determine what were the requirements necessary to put the bulged ships on an equality with the others as regards resistance to rolling. The paper, which we hope to reprint at a later date, provided the result of the experimental work. In consequence of what was found, bilge keels were added to the vessels dealt with, but they were of smaller dimensions than those on the unbulged vessels. The rolling characteristics were then decidedly better.

In the absence of Professor Kyoji Suyehiro, the President asked Sir John Biles to present, in abstract, his paper on "The Drift of Ships caused by Rolling among Waves." To study the actions a special tank, 30 ft. long, 10 ft. wide and 2¾ ft. deep, was constructed. The waves for the experiments were formed by a wooden flap driven by an electric motor through mechanism composed of a train of spur wheels, and crank and connecting rod, arranged so that the stroke could be adjusted at will. The reflections from the far wall of the tank were quenched in order to prevent the formation of stationary waves. Whenever the model was subjected to waves the mean position of the strings which supported it was not perpendicular to it, but always inclined more or less to the direction of propagation of the waves. It was still more peculiar that the inclination of the strings appeared to depend upon the extent of the roll. The tendency to drift became more conspicuous, as the rolling increased and its magnitude depended upon the ratio of the natural period of rolling of the model to the period of the waves. It was found that when the period of the waves was longer than the natural period of the rolling of the model it behaved as though it was a part of the water. Under conditions of synchronism, and in the cases where the period of the waves was shorter than the period of the model, disturbance of the structure of the waves was caused by the model. This disturbance was most remarkable in the case of synchronism and more conspicuous on the weather side than on the other. The ship as a whole, or her centre of gravity, had an orbital motion, though not quite the same as that of the particles of the waves. The disturbance of the waves by an unrestrained ship was thus different from that caused by a fixed ship. In the former case the disturbance was mainly due to rolling, whilst in the latter it was only due to the obstructing action of the ship herself. When a ship or waves was set into a state of forced rolling, and the waves kept the same form on both sides of the ship, there was no force to cause the drift in one direction, except the horizontal to and fro motion, because each side of the ship was subjected to equal and opposite actions of the waves alternately. As a matter of fact, the mutual actions between the sides of the ship and the waves were found to be not the same on the two sides. This was explained as being due to the fact that the pressure on the foreside of a plane moving through water was larger than the suction pressure on the rear side. During the first half-cycle of the rolling, when the weather side pushed the water, the ship was subjected to a drifting force in the direction of the progression of the waves, while during the second half-cycle, when the same side was receding from the water, a drifting force of less magnitude acted in the opposite direction. The results of the tests were given and the drifting forces deduced from them. Remembering that yawing was induced as a combined effect of rolling and pitching, Professor Suyehiro suggested that an anti-rolling device of some sort was necessary to protect a ship from these actions and to keep her on a straight course in a rough sea.

Sir John Biles, after concluding his presentation of the main features of Professor Suyehiro's paper, expressed his thanks to Mr. Payne for his admirable contribution, and stated that the paper reminded him of the work done by his predecessor, Mr. R. E. Froude. The Institution and the Nation must be congratulated on having such a well-qualified successor to the pioneers of experimental tank work.

Professor J. J. Welch, D.Sc., said Mr. Payne's experiments confirmed the earlier results of similar work, but in the case of bilge keels a great advance in knowledge was given by them. It was rather interesting that the Admiralty had, from practical considerations, dropped the use of bilge keels on two occasions, but had reverted to their use. Although the new forms used were smaller than was common, they were found useful for the purpose for which they were installed. Another point that was brought out by Mr. Payne's tests was that rolling was greater when under way than when at rest with an apparent exception when bilge keels were fitted. The effects of the resistance of the bilge keels lengthened the periods of rolling. This was shown in earlier experiments. The Admiralty deserved their thanks for allowing these results to be published.

Mr. E. L. Attwood, R.C.N.C., stated that the paper on rolling was further evidence of the value of model experiments. The question tackled was one of practical importance, namely, the effect of the presence and the length of bilge keels on rolling. The original bilge keels fitted to the Royal Sovereign class were 350 ft. in length or 60 per cent. of the length of the vessel. After the bulge was fitted, the tests showed that bilge keels of 200 ft. length, or 35 per cent. of the length of the ship, were all that was necessary. In dealing with the selection of length, the author had decided that bilge keels of 200 ft. length represented the requirements for the freedom from rolling sought for, but he might say if it was also the most desirable length to fit.

Mr. Lloyd Woollard, R.C.N.C., said Professor Suyehiro had given reasons for believing that the drift of a ship in waves was due to circumstances independent of the waves themselves. He showed it was due to the rolling of the ship and its size, and had proved his case. In dealing with any irrotational wave, forward surface drift must take place, and this effect must account for some of the actions experienced. The study of rolling had been neglected for some time. In warships they had to provide elaborate arrangements to make possible the accurate firing of guns, because of rolling, while the effects of rolling in the case of passenger vessels needed no comment. The only way to understand the causes of these actions was to investigate them, and Mr. Payne had provided very valuable information, which it was hoped he would extend by dealing with other types of vessels. The bulge acted as a sort of bilge keel in itself, but the magnitude of its acting so had to be investigated. He preferred to deal with the reciprocal of the freedom coefficient in dealing with such questions. Plotted, the results then gave a straight line rather than the curve obtained with the freedom coefficient itself. Again, it was easier to understand the significance of resistance rather than its opposite. The diagrams showing the variation of the freedom coefficient with speed of the model in still water showed, in the case of vessels without bilge keels, the same characteristics, but the effects of speed when bilge keels were fitted gave changes in the freedom coefficient that were quite irregular. It should be noted that the synchronous wave was a very long wave. The theoretical maximum amplitudes, due to the superposing of the forced and the free rolls, were not in agreement with the results obtained. The only suggestion that could be made was that little was known of the real sub-surface moment acting upon a ship. Quite likely a lower sub-surface than the calculated one was the correct one in the cases tested.

Mr. J. H. Narbeth, C.B., concluded the discussion by referring to the stages in the study of rolling.

Mr. M. P. Payne, in reply, said it was a necessary thing for the Admiralty to conduct these enquiries, as there was nothing available. The length and area of bilge keels adopted was obtained by changing the conditions. The bilge keel was changed by cutting away in three stages to obtain the information on the requirements to give the same rolling characteristics to the bulged ships as had been obtained with the unbulged ones. Mr. Lloyd Woollard's suggestion of plotting the reciprocals of the freedom coefficient had not occurred to him. It must be remembered, however, that the freedom coefficient had a definite physical meaning. He had noted the irregular effects of the bilge keel under way at certain speeds.

The Duke of Northumberland expressed the indebtedness of the Institution to the authors for the presentation of the results of the successful work which was recorded in the papers, and wished to congratulate Mr. Payne on his continuing with distinction the great work of the late Mr. R. E. Froude.

STEAM TURBINE-DRIVEN AUXILIARIES.

The meetings were resumed on Thursday evening, under the chairmanship of Engineer Vice-Admiral R. B. Dixon, C.B., who called upon Mr. R. W. Allen, C.B.E., to read his paper on "The Application of Steam Turbines to Auxiliary Machinery." This paper was reprinted in abstract in ENGINEERING of April 11 (see page 477).

Brigadier-General James G. Weir, C.B., in opening the discussion, said that the development of steam-turbine auxiliaries had been somewhat slow because of the excellence of the high-speed reciprocating machinery available. The author had given information regarding weight, space occupied and steam consumptions, but he (the speaker) believed that when full comparison of all the features was made, that it would be the secondary differences that would turn the balance in favour of the turbine. These were the possibility of using high superheat and the freedom from oil in the exhaust. The turbine feed pump had been used for feeding in large boiler installations, such as the Berengaria, the Majestic, and in large electric power stations. That it was eminently suited to the work was demonstrated by the inspection of the very small and light rotor of a feed pump unit, which had run for 2½ years, and fed boilers for a plant of 15,000 h.p. Actually one million tons of feed water had been dealt with each year by the specimen shown. In the Berengaria three turbine units, weighing 9 cwt., had replaced eight direct-driven sets weighing 98 cwt. The main circulating pumps of the Queen Elizabeth, working with steam at 190 lb. pressure and exhausting at 25 lb., had given consumptions of 86·5 lb. of steam per horse-power. There could be no doubt that the proper way to obtain efficiency was to make use of gearing, and with it in use examples had been found with consumptions as low as 39·4 lb. of steam per horse-power. He noted the claims made for an automatic balancing device for turbine pumps, that it ensured satisfactory working when delivering small quantities of water. He was afraid he had to admit that working under port conditions was the weakness of all turbine machinery. He would like to know of any new developments in that direction.

Mr. S. V. Goodall, R.C.N.C., stated that as the result of the Washington Treaty, they were all seeking earnestly to save weight and space in war vessels. The economy of fuel and fittings was less important. In dealing with the advantages of turbine auxiliaries, the author referred to the questions of saving in overhauls and renewals and the greater reliability of the turbine units over long periods of running. That was an important matter. He would like to be able to reduce the size of the workshops which had to be arranged for in war vessels, and thus reliability and freedom from breakdown was a vital consideration. The Admiralty practice was to have separate condensing plant for the electric generating plant. Although the turbine direct-driven set did not compare favourably with the reciprocating set, the balance was in favour of the geared turbine set. When Diesel engines were used the weight of 29 tons for a 300-kw. set and the greater space it occupied than turbines was a high price to pay for the privilege of using internal combustion engines. In warships the use of turbine-driven bilge pumps did not offer so many advantages as were suggested in the paper. The saving in pipes could not be realised because of the many compartments. Electrically driven bilge pumps could be obtained which worked submerged in the water. He wished that he could believe all that was said in favour of the turbine driven fan. With a view to ensure absence of vibration in torpedo tubes and guns, turbines might be installed in place of reciprocating units, but in some cases when the matter was worked out in detail an actual increase in weight resulted instead of the expected decrease.

Admiral Dixon congratulated the author on his able and informative summary of the claims of the turbine-driven auxiliary. The value of the contribution would have been even greater if the consumptions of fans and feed pumps at reduced powers were given. In the Navy the ships mostly ran at reduced powers, and these figures would be of great service.

Mr. R. W. Allen, in reply, said he had experienced difficulties, because of the magnitude of the subject, in preparing a paper to bring before engineers, and also to call the attention of ship constructors to the advantages of the steam turbine. The paper was made a general one for that reason, and he therefore did not deal with details or types. Details and developments might be presented in further papers on this important subject. He would meet the requests of the speakers for the additional consumptions, in the paper he had only given tables on a comparative basis. General Weir had given them a good concrete example of the small size and reliability of turbine units with his exhibit of the rotor, and had contributed two valuable points regarding superheat and the absence of oil in turbine exhaust. Steam plant, if it must compete with Diesel engines, must be worked at high pressures and at high superheats. Under these conditions turbine-driven auxiliaries had great advantages over reciprocating sets. He would suggest to Mr. Goodall that if the ships of H.M. Navy were fitted with steam-turbine auxiliaries, the space needed for workshops could be used for other purposes. The electric bilge pump was only a toy, whereas the turbine set could be obtained in units capable of dealing with 1,500 tons of water per hour and could be installed without any pipes whatever. It was difficult to answer the questions relating to saving in weight with fans without the plans of the ship. He could, however, state that in the case of B class cruisers turbo-fans showed a saving of six to seven tons per ship over reciprocating sets, and he assumed that was important enough to warrant consideration. It was only now possible to see all the advantages of geared turbine driving, and its adoption to reduce steam consumption would prove a great advance in the mercantile marine and the Navy.

HIGH ELASTIC LIMIT MILD STEEL.

Mr. A. T. Wall, A.R.C.Sc., was then called upon to read a paper on "High Elastic Limit Mild Steel and its General Application," contributed by Messrs. G. W. Barr, F. G. Martin, B.Sc., and himself. This paper is reprinted elsewhere in this issue.

In opening the discussion, Dr. Milton said he thought the paper of importance, but he regretted that the authors had given very little information, and consequently the members could not judge the full significance of the suggestions. After speaking at length on elementary matters relating to the methods by which the characteristics of steel could be improved and referring to some of the changes it undergoes in heat treatment, he discussed the difficulty of carrying out the process with steel plates in bulk. He was satisfied that no steel works in this country could heat-treat the plates for a ship if the work was carried out uniformly. It must not be thought that the steel they were using was defective, or that its elastic limit was only eight tons per square inch. Twenty years ago the term elastic limit meant the highest stress to which the plate could be subjected without deformation, whereas the authors used it as meaning the limit of proportionality. Pieces of plate, however, did not give reliable or consistent results, and test pieces should be turned into cylindrical form before testing.

Mr. T. M. Service found it difficult to understand just exactly what the authors were attempting to put before the Institution. His firm, recognising that mild steel subjected to severe shocks became brittle, suggested to the Admiralty that they could supply material having a high limit of proportionality and possessing great toughness under these conditions. The Admiralty asked them if they could produce a material with a limit of proportionality of 18 tons, which they, the Admiralty, afterwards reduced to 17 tons. The firm agreed to do so, and orders were placed. The first material to this specification was supplied by Messrs. Beardmore in 1922, and after tests the Admiralty adopted it and placed it on their schedule. Steels with high limit of proportionality only retained this, in combination with ductility, if they were worked into the structure cold. If heated, the limit of proportionality might be reduced, or if the composition was such that it was not reduced, the ductility would usually be impaired. As a result of experiments, his firm had got over these troubles and produced a steel which could be worked hot without changing its characteristics. It was also not brittle like mild steel under severe shock. Tests gave these results:—

Specimen.	Limit of Proportionality.	Yield Point.	Ultimate Strength.	Elongation.	Reduction of Area.
⅞-in rivet ..	24·0	28·0	37·9	25 per cent. on 1½ in.	64 per cent.
1¼-in rivet ..	26·0	30·0	40·2	25 per cent. on 2 in.	60·4 per cent.
After heating to 900 deg. C. for 30 minutes and cooling in air.					
⅞-in rivet ..	22·0	28·0	38·9	25 per cent. on 1½ in.	50·0 per cent.
1¼-in. rivet ..	25·0	29·0	37·2	26 per cent. on 2 in.	59·0 per cent.

These tests showed that the heating had not impaired the ductility or reduced the limit of proportionality below the value originally specified 18 tons. His experience led him to believe that it was not possible to have an elastic limit of 16 tons to 17 tons for a steel with an ultimate tensile strength of 30 tons. There was no such thing in commercial work as 100 per cent. efficiency in electric welding, and the material referred to could not be welded and retain its properties.

Mr. E. L. Attwood, R.C.N.C., said he had great difficulty in finding out where the authors' steel was being made. He also referred to the Admiralty experience over many years with high tensile steels.

Dr. Montgomerie was surprised at the claim made for appreciated modulus. He was not satisfied that additional riveting was necessary with such a steel. In his opinion, with electrically-welded butted plates with the edges chamfered the maintenance of ductility throughout the joint was not possible. He would like to know the elastic limit of the steel in compression, and thus see how it compared with the value in tension.

Mr. W. Simons stated that his firm had supplied the Admiralty for many years with H.S.T. steel of which the ultimate tensile strength was 33·6 tons and the elongation 23 per cent., while the elastic limit was 20·4 tons. There was no difference between this steel and that spoken of by the authors.

Mr. Martin, in reply, said that the steel referred to by Mr. Service, since it had an ultimate strength of 37 tons to 43 tons, was not comparable with that described. The steel referred to in the paper was a heat-treated steel. Six thousand tons of this steel were recently ordered, and the elastic limit of 15 tons was specified instead of the 16 tons to 17 tons mentioned in the paper. This was not because they could not get the higher figure, but because the naval architect preferred to keep something in reserve. There was no more difficulty in working the new steel than was experienced with any non-heat-treated steel. Dr. Montgomerie had called attention to the increase of the modulus of elasticity. The increase was small, but was an experimental fact, and investigations were being made to find the cause of the increase. He was not able to give further information on compression tests. Although steel referred to as giving 17 tons to 18 tons for the limit of proportionality was used by the Admiralty, the highest figure for that value which he had come across was 10·55 tons.

Mr. Wall also replied, and stated that Dr. Montgomerie apparently did not take into consideration that as the plates would be thinner, smaller rivets would be used in accordance with the usual shipbuilding practice. The V-butt welded joint was not the only one available, and it was not proposed that it should be used.

Admiral Dixon, in closing the meeting, tendered the thanks of the members of the Institution to the authors for their paper.

(To be continued.)

ROYAL INSTITUTION.—The after-Easter session at the Royal Institution will commence on Tuesday, April 29, when Professor Barcroft begins a course of four lectures on "The Effect of Altitude on Man." The Tyndall lectures will be delivered this year by Major M. S. Tucker, Director of Sound Ranging in the Army on "Acoustical Problems." Other lectures are announced, among which are two by Dr. E. V. Appleton on "Atmospheric Interference on Wireless Telegraphy."

THE BRITISH EMPIRE EXHIBITION POWER STATION; FEED PUMPS.

CONSTRUCTED BY MESSRS. WORTHINGTON-SIMPSON, LIMITED, ENGINEERS, LONDON.

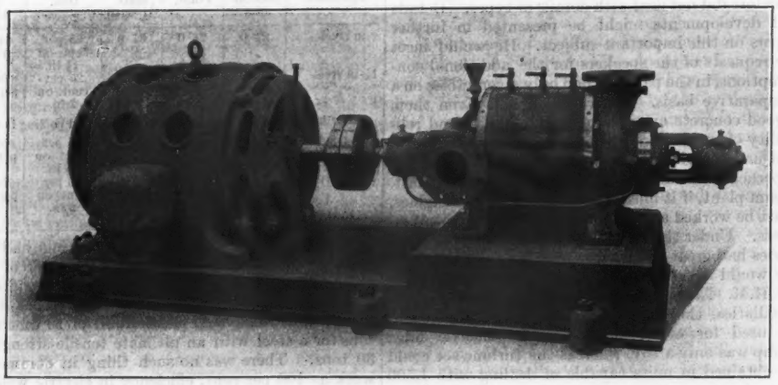


Fig. 71.

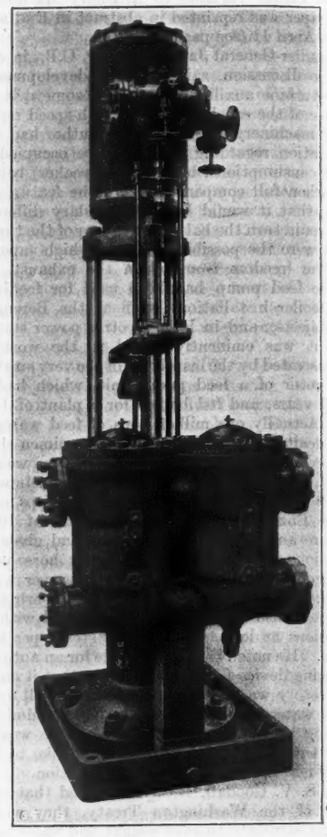


Fig. 72.

THE POWER STATION OF THE BRITISH EMPIRE EXHIBITION.

(*Concluded from page* 458.)

In our preceding articles we have dealt in considerable detail with the boiler plant and the main generating units at the Wembley power station, and before concluding the series it is fitting that mention should be made of some of the auxiliary apparatus. There are two feed-pumps installed for the four boilers, both being manufactured by Messrs. Worthington-Simpson, Limited, of London and Newark-on-Trent. These pumps are situated in the turbine-room basement close against the boiler-house wall. In conformity with the general object of the power-plant design, namely, to exhibit as many types of machines as possible under working conditions, the two pumps are of different design. One is of the vertical direct-acting reciprocating pattern, the other being of the centrifugal type driven directly by an electric motor. These two pumps are illustrated in Figs. 71 and 72, annexed. The pump shown in the latter figure has steam and water cylinders of 14 in. and 10 in. diameter respectively, with a 24-in. stroke. It is suitable for a steam and water pressure of 300 lbs. per sq. in., and will deliver 100,000 lb. of water per hour when running at its normal speed of 15 double strokes per minute. The pump is of the makers' standard construction, and is fitted with Worthington-Simpson Simplex valve-gear.

The pump shown in Fig. 71 is a 4-in. centrifugal, specially designed for boiler-feeding purposes. It comprises four stages in series, and will deliver 100,000 lb. of water per hour against a total head of 550 ft., or 240 lb. per sq. in. when running at a speed of 2,880 r.p.m. It is driven by a 50-b.h.p. squirrel-cage motor supplied by Messrs. Crompton and Co. Limited. It will be noted that each of the pumps mentioned can normally supply the whole of the feed-water required by the boiler plant when all boilers are steaming at their rated capacity. The water level in the boilers is maintained constant by feed-water regulators. The John Thompson boilers being fitted with regulators supplied by The Crosby Valve and Engineering Co., Limited, and the Babcock and Wilcox boilers having Cope regulators supplied by Messrs. James Gordon and Co.

Coal is brought to the ferro-concrete bunkers, from which it descends to the chain grate stokers as required, by means of a coal handling plant of the Mitchell Conveyor and Transporter Company, Limited of London. As the power-house is in the Machinery Hall of the Exhibition itself, it is not possible to bring coal very near the boiler house by rail, and hence a somewhat elaborated conveying system has had to be installed, totalling about 500 ft. in length without reckoning elevation. The coal trucks are discharged by a Mitchell tippler, which we hope to describe in some detail later. They are pulled to and from the tippler by an electric capstan supplied by Messrs. Ransomes and Rapier, Limited. The first transportation of the coal is effected by a belt conveyor 51 ft. 3 in. long, which carries it to the main conveyor running at right angles to the first conveyor. The main conveyor is also of the belt type, and is 347 ft. 3 in. in length between centres. It runs in a tunnel under the Machinery Hall, and delivers the coal continuously into a shoot which terminates in a pit in the basement of the boiler-house. An automatic skip descends periodically into this pit, and by its descent opens the door of the shoot and receives a charge of coal. This is raised vertically to the top of the boiler-house and emptied automatically into a hopper supplying the conveyor running along the top of the bunkers. This again, is of the belt type and is nearly 100 ft. long. It is provided with a tripping device which can be set at any point so as to deliver the coal at any required place along the bunkers. The coal supply is weighed to the bunkers by two automatic continuous weighing machines placed in the run of the main conveyor, one of Mitchell's own manufacture and the other supplied by Messrs. Denison and Son, Limited. The conveyor from the tippler runs at a speed of 245 ft. per minute; the main conveyor and that above the bunkers both run at a speed of 280 ft. per minute. The belting used is of 4-ply cotton duck, 16 in. wide, with a face of solid rubber $\frac{1}{8}$ in. thick on the carrying side. The belts run on ball-bearing idlers, which are damp and dust proof, and the lessening of friction by these idlers as compared with ordinary ones, not only considerably reduces the power required for the conveyors, but reduces the tension in the belts, and thus contributes to their durability. The idlers require greasing only about once a year.

Another important item of the power-house auxiliary equipment is the cooling tower installation for reducing the temperature of the circulating water. Two cooling towers have been installed, one of the Bradford type, by the Davenport Engineering Company, Limited, and the other by the Premier Cooler and Engineering Company, Limited. These towers are of the usual creosoted wood construction built over concrete tanks, and a ladder between them gives access to a platform which communicates with the interiors at the entrance level of the water. Both towers are of the natural draught type, designed each to cool 175,000 gallons of water per hour from 92 deg. F. to 75 deg. F. under summer conditions. The towers are situated outside the outer wall of the power station and their existence might hardly be known to visitors to the Machinery Hall. They are, however, very visible to travellers who enter the Exhibition by the Never-Stop Railway.

The main switchboard, controlling the three turbo-alternators, the various feeders and the main substation adjoining the engine-room has been supplied by Messrs. A. Reyrolle and Co. Limited, of Hebburn-on-Tyne, and is of the metal-clad type developed first by that firm. The board comprises three generator panels with Merz-Price protection devices, four transformer panels with overload protection, one incoming feeder panel controlling the 10,000-volt supply from the North Metropolitan Company, and having overload time-limit protection, three rotary converter panels with overload time-limit protection, three feeder panels with overload definite time limit protection and with the split conductor system of protection, one feeder panel and one bus-coupler panel, also with time limit overload protection. The switchgear is of the remote electrically operated, duplicate busbar type, the control switches being mounted on a slate panel board. The general appearance of the switchgear is most neat and workmanlike. The switches are of the oil-immersed type having very heavy cast steel top plates and welded boiler-plate steel tanks, and have a breaking capacity of 250,000 k.v.a.

Simple mechanical interlocking devices prevent apparently every conceivable misuse of the gear by ignorance or carelessness, and the most complete safety is secured to the operator. When any switch is withdrawn for isolating purposes, which cannot be effected unless the main contacts have been previously opened, the orifices leading to the live contacts are automatically closed, and can be padlocked if desired. This gives absolute protection to men working on the line, against current being put on without the authority of someone responsible The enclosure of all conductors and insulators reduces the work of cleaning, inspection and testing

HIGH POWER SINGLE PULLEY UNIVERSAL MILLING MACHINE.

CONSTRUCTED BY MESSRS. ALFRED HERBERT, LIMITED, ENGINEERS, COVENTRY.

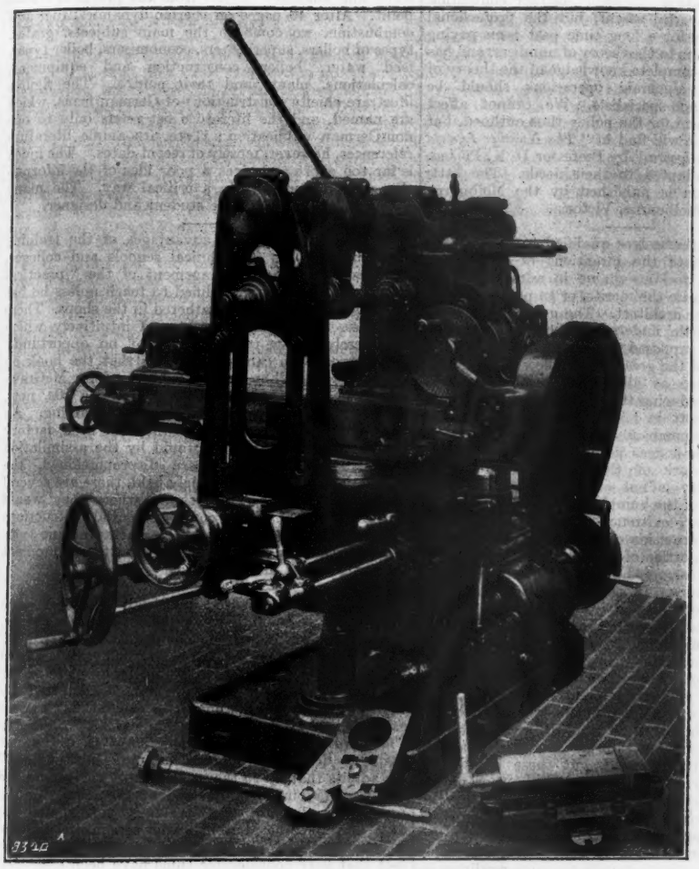


Fig. 1.

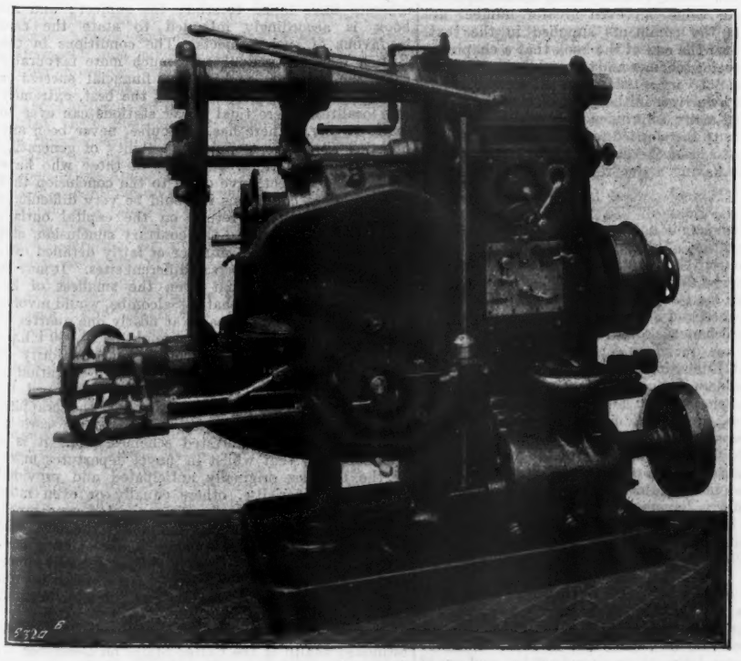


Fig. 2.

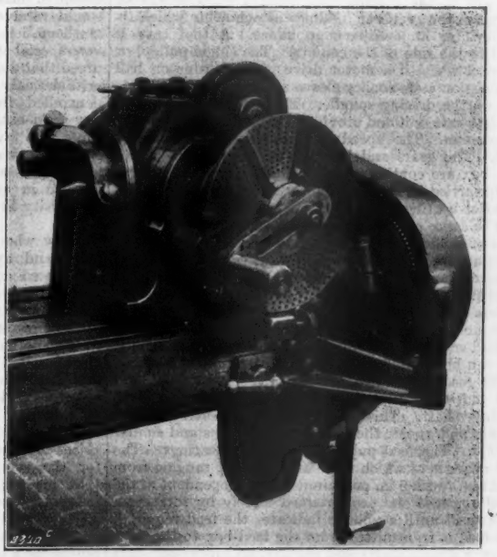


Fig. 3.

to a minimum, and, further, it protects the insulation from fumes, moisture, dust and vermin. The spaces containing the busbars and other conductors are filled in solid with insulating compound, so that there are no air spaces in which vapour from the oil in the tank can collect and form an explosive mixture. The switchgear is entirely self-contained and envolves no concrete cells or other special structural work.

There are, as will be readily understood, a very large number of items in the power station which it is quite impossible to deal with separately in a description such as that which we have given. With the exception of certain integral piping between boilers, superheaters, economisers, &c., the whole piping systems for the steam, feed water and circulating water of the plant, including all small piping and connections, has been carried out by Messrs. Stewarts and Lloyds, Limited. The valves in connection with all this piping have been supplied by Messrs. Dewrance and Co., Limited, Blakeborough and Co., Limited, Glenfield and Kennedy, Limited, Alley and MacLellan, Limited, and The Clayton Valve Company, Limited. The measuring apparatus for coal, water, steam, temperature, &c., is on such a complete scale that we propose to deal with the whole of the equipment of this kind in a later article, in view of the primary importance of adequate metering apparatus in the efficient management of power stations generally.

UNIVERSAL MILLING MACHINE.

We illustrate on this page one of the most recent types of high power milling machines manufactured by Messrs. Alfred Herbert, Limited, of Coventry. It has a single-pulley ball-bearing drive, needing no countershaft, but may be equally conveniently driven by a silent chain from its own electric motor mounted low down at the back of the machine. In the design the convenience of the operator has been considered in connection with every manipulation required when working. The machine is started and stopped by a friction clutch operated from the front of the knee, feeds are engaged, disengaged and reversed, and all slides are clamped from the same position. Handwheels are provided for longitudinal, traverse and vertical motions, and quick movements by power are possible in all directions. The driving-box, feed-box, feed-gears and table slides are all automatically lubricated. Speed changes are made by sliding gears and all spindle speeds are reversible. All feeds have automatic and safety stops and the feed levers on the

knee are interlocked for safety, so that no conflicting feeds can be engaged simultaneously.

The column is cast in one piece with the base and carries the spindle and overhanging arm. The base is lipped all round to form a pan. The Vees extend to the top of the column and form a rigid means of carrying the vertical milling attachment which is supplied as an auxiliary appliance. A tool tray is fixed to the side of the column. The single-pulley, or sprocket wheel if a motor drive is used, runs on ball bearings on a stationary sleeve so that there is no side pull on the driving spindle. The driving box is built as a separate unit and provides 16 speeds in geometrical progression. The speed change levers are made of steel. The gears and bearings in the drive box and feed box are continuously flooded with oil by a force pump carried inside the column. The arm brace forms an outer-bearing for the arbor, enabling the arbor support to serve as an intermediate bearing when using a gang of milling cutters on heavy work. For use with small arbors or solid cutters a dead centre with screw adjustment is included with the equipment. A roller steady for supporting the arbor against the thrust of the cutters can be clamped to the overhanging arm, and is a great convenience on many classes of work. It can be applied without removing the cutters from their arbors, and can be swung out of the way when not in use.

The feed-box, which contains Herbert's patent dial feed motion is driven by a wide belt from the first driving shaft. This provides the necessary safety feature and avoids the use of shearing pins and similar devices. The feed pulleys run on ball bearings. The feed changes of which there are eighteen, ranging from 0·625 in. to 22·5 in. per minute, are independent of the spindle speeds and are obtained merely by rotating a handwheel until a pointer indicates the feed required. The feed is transmitted from the feed-box to the knee by very strong shafts and gearing, no universal joints being used. The gearing of the feed mechanism is of steel, hardened where necessary.

The vertical knee slide is clamped by a steel lever in front of the knee, so that the operator has not to go round the table to the back every time the knee has to be clamped or unclamped for putting on the cut. The clamping is effected along the full length of the slide by moving the taper gib endwise by a rack and pinion.

The Universal dividing head, shown in Fig. 3, is of very strong design. The swivelling block is mounted on large trunnion bearings and is clamped round a complete circle at any angle from 15 deg. below the horizontal to 8 deg. past the vertical. The angular adjustment is graduated and is provided with a vernier reading to 5 seconds of arc, or one-twelfth of a degree. The spindle is of large diameter, and has a taper hole uniform with the taper hole in the main spindle of the machine and also a hole clear through, so that a draw bolt can be used when required.

Each machine includes provision for three different methods of indexing, enabling a great variety of divisions to be obtained. Direct indexing gives seven different numbers ranging from 2 to 24. By plain worm indexing all numbers up to 60, all even numbers up to 120 and all numbers divisible by 5 up to 120 are obtainable, as well as many other numbers up to 2,640. The arrangement for differential indexing provides for all divisions up to 400 including the prime numbers. Spirals can be milled with the standard set of change gears varying from 0·694 in. to 144 in. pitch. Provision is also made for milling an unusually wide range of tapers between centres, the centres being truly in line with each other.

The longitudinal feed of the machine is 28 in., the transverse feed 9½ in. and the vertical feed from centre of spindle ½ in. to 18 in. The working surface of the table is 51½ in. by 12 in., and it has a maximum angular adjustment of 46 deg., each side of its central position. The overhanging arm is 4½ in. diameter, the centre of this arm to the centre of the spindle is 6½ in. The sixteen spindle speeds range from 16·5 to 427 r.p.m. The dividing head swings 12½ in., or 16⅜ in. with raising blocks, and a length of 29 in. is admitted between the head and the tailstock. The net weight of the machine is 5,600 lb., and it absorbs about 10 b.h.p. for medium work.

ELECTRIC CABLES FOR MOTOR CARS.—A publication just issued by the British Engineering Standards Association gives the British standard specification for electric lighting and starter cables for use on motor cars. The specification gives the dimensions of cables for normal pressures of 6 volts and 12 volts, but does not deal with the composition, quality or durability of the insulating material. It is divided into seven sections of which four relate to various types of lighting cables, while the remainder are concerned with starter cables. Three types of covering, viz., braided and compounded, metallic armoured, and cab-tyre sheathing, are dealt with for both classes of cable. Copies of the specification, which bears the number 5002–1924, may be obtained from the Publications Department of the Association, 28, Victoria Street, London, S.W.1, price 1*s.* net or 1*s.* 2*d.* post free.

NOTES ON NEW BOOKS.

GAUSS claimed that mathematics was the queen of the sciences, and that arithmetic, in which he was mainly concerned with the theory of numbers, was the queen of mathematics. Probably neither contention would receive universal assent, but the professional mathematician has for a long time past been paying very special attention to the theory of numbers, and has urged that a more complete knowledge of the theory of arithmetical and algebraic operations should be demanded from non-specialists. We cannot affect any great enthusiasm for the policy thus outlined, but those who favour it will find in "*The Number System of Arithmetic and Algebra*," by Professor D. K. Picken, a testbook well adapted to their needs. The little treatise in question is published by the Melbourne University Press, Melbourne, Victoria.

Many who feel themselves qualified to criticise the work and appreciate the intentions of the artist, usually so called, feel no shame in admitting their incapacity to appraise the merits, or to pass judgment on, the work of the architect. The guiding principles of his craft, are little understood. His opportunities for distinction are supposed to have been exhausted by the construction of the great masterpieces of the past and he is regarded as filling the humbler task of adapting and reproducing these acknowledged models. Mr. Charles Marriott in his book, "*Modern English Architecture*" (Chapman and Hall, Limited, London, price 21*s.* net) challenges this attitude. He pleads for the artistic work of the architect; he claims that his originality is not exhausted, and that he influences the life of the humblest among us. In these days, when the very existence of the nation seems to depend upon the provision of suitable and convenient homes for a large portion of the community, we like to be assured that instructed guides are ministering to our social necessities. In this crisis, we expect the architect to concern himself in very humble details. The time has gone by when Bernini thought himself warranted in complaining that regard for interior convenience in building was unworthy of a great architect. The author does not subscribe to Bernini's elevated opinion, and contemplates work on a much lower plane, but we find it difficult to appreciate his argument. The influence of ancient architecture is too apparent throughout. In an interesting manner, many subjects are discussed, but these have little to do with modern architecture. The author pleads that the introduction of history is justified by the fact that architecture has its roots in tradition, and that its correct appreciation demands reference to the Greek and Gothic revivals of the XIX century. Accepting this explanation we turn with the more readiness to the illustrations by which are indicated what has been accomplished in the last 50 years. These illustrations, excellent in their way, are not so instructive as they might be, owing to many being unaccompanied by description, while an even greater number are separate from the comments supplied in the text. It is not till near the end of the book that a chapter is devoted to housing schemes and town planning, and the information is not very satisfactory. It exhibits what has been done by private initiative in various directions, demonstrating many improvements, but offers little or no guidance to the worried town councillor honestly endeavouring to meet the demands of the Ministry of Health, while having a due regard to the necessities for economy.

A mining student is not a student of a mining and engineering college. What Mr. T. H. Byrom, F.I.C. means by the word "mining student" in his volume on "*The Physics and Chemistry of Mining. An Elementary Class-Book for the Use of Mining Students*" (London: Crosby Lockwood and Son, price 6*s.* net), is clear from the list of miscellaneous questions which he adds to his volume. Those questions comprise problems set for the Board of Education Examination in mining and by the examiners for colliery managers' certificates. Mr. Byrom's chapters on atmosphere, the gas laws, water, carbon, fire damp, miners' lamps, explosives, coals, fuel economy and water softening seem to be quite suitable for the instruction of the young miner. One might miss general reference to electricity; but electricity has become almost a science to itself. The MacGregor-Morris anemometer, which involves a Wheatstone bridge, is illustrated. Mr. Byrom's book is already in its fifth edition; the first edition appeared in 1905.

The first edition of "*Die Dampfkessel nebst ihren Zubehörteilen und Hilfseinrichtungen*," of which the second edition is now before us (Berlin: Julius Springer, price 9·70 dols., bound), came out in 1911. The war delayed the completion of the second edition, and one of the two authors, Fr. Schneiders, died in 1919; his place has been taken by A. Rüster, director of the Bavarian association for steam boiler revision. The other original author, Professor R. Spalckhaver, of Altona, near Hamburg, has had the further assistance of several experts. The quarto volume of 481 pages, with 810 text figures, deals with steam boilers and their accessories and auxiliary devices from the practical standpoint. After 40 pages on thermo-dynamics, fuel and combustion, we come to the main subjects, grates, types of boilers, superheaters, economisers, boiler types, feed water, boiler construction and equipment, calculations, plants and their control. The figures illustrate chiefly constructions of German firms, which are named, and the literature list refers only to one non-German publication; there are ample literature references, however, mostly of recent dates. The index is far too short and gives a poor idea of the information offered, generally in a critical way. The many tables will be useful to the student and designer.

We hear much of the advantages of the training given by teachers in technical schools and colleges, and always to the disparagement of the "practical man." But no one is qualified to teach unless he has had a lengthy experience gathered in the shops. There many essential details are learned intuitively which the merely college-trained man has no opportunity to observe. One can hardly think that the book on "*Foundry Work*," by R. E. Wendt (London: McGraw-Hill Publishing Company, Limited; price 10*s.* net), has been written by a man with a shop training. An intelligent youth spending six months in a factory would learn more than he would by the assimilation of this book. Drawings are disproportioned, the instructions given are extremely bald, there are several gross errors. Gaggers are shown where they would cause a drop out of the cope. Essential instructions are omitted. Exercises and a long array of questions have an academic aspect, yet many matters of moment are not so much as mentioned.

It was an experienced politician who gave the advice that we should never prophecy unless we knew. This maxim was disregarded by the late Sir Frederick Bramwell, who some 40 years ago confidently asserted that in 50 years time steam would be obsolete as the working medium of heat engines. Undeterred by what Mr. Tony Weller would have called this "wicious example," Mr. Norman Davey prefaces his "*Studies in Tidal Power*," with the prediction "that the gas turbine is destined to supersede all other heat engines." He admits that up to the present most engineers have not been favourably impressed by the results of the many experimental gas turbines constructed to date, but since he attributes this pessimistic attitude to ignorance it would seem that he is unaware of the fact that very considerable sums have been expended by British engineers in investigating the matter both theoretically and experimentally. He similarly contends that those who are dubious as to the commercial possibilities, under present conditions, of tidal power schemes have failed to study the subject; and his book is accordingly intended to state the case in favour of such projects. The conditions in the British Isles are undoubtedly much more favourable than the average, and unless financial success is practicable here there will be, at the best, extremely few localities where tidal power stations can ever be made to pay. There has, of course, never been any question as to the technical feasibility of generating power from the tides, but most of those who have studied the subject have come to the conclusion that under present conditions it would be very difficult to earn any reasonable return on the capital outlay. Mr. Davey has come to the contrary conclusion, and he gives in his book a number of fairly detailed estimates of construction costs at different sites. It may be remarked, however, that even the smallest of his proposed installations, that at Salcombe, would involve an outlay which he estimates at nearly one quarter of a million. The plant capacity would be 14,000 b.h.p., which is about double that of the vast majority of electric power generating stations now in operation in this country. Even these have been developed by slow stages, and the process has involved the scrapping of much obsolete machinery. Few people care to risk large sums on untested schemes, since it is a commonplace, that whilst in novel departures many of the troubles originally anticipated and provided for never materialise, others equally or even more formidable are apt to make an unexpected appearance. Mr. Davey probably makes out about the best case possible for tidal power schemes under existing conditions, and those interested in the matter will appreciate the data he has collected. The volume is published by Messrs. Constable and Co., Limited, ta 32*s.* net.

WEALTH OF THE UNITED STATES.—The preliminary estimated wealth of the United States on December 31, 1922, is fixed by the Department of Commerce at 320,803,862,000 dols., an increase of 72·2 per cent. over the figure for 1912.

INDUSTRIAL NOTES.

MR. A. J. COOK, miners' agent for the No. 1 Rhondda district, has been elected secretary of the Miners' Federation of Great Britain, in succession to Mr. Frank Hodges, M.P., and Civil Lord of the Admiralty. Mr. Cook obtained 217,664 votes, Mr. J. Jones, of Yorkshire, following with 202,297.

The result of the miners' ballot was announced last Friday. It showed that votes cast for the acceptance of the owners' terms were 322,392 and against 338,650, a majority against of 16,258. The districts of Durham, Northumberland, North Wales, Yorkshire, the Midlands and the enginemen showed substantial majorities in favour of the owners' offers, whilst in South Wales 58,490 voted for and 101,613 against. On the same day the Labour Ministry issued a statement to the effect that "the Executive Committee of the Miners' Federation met Mr. E. Shinwell, Secretary for Mines, and reported to him the result of their ballot on the owners' wages offer. Mr. Shinwell discussed the situation with the Executive Committee and afterwards with representatives of the owners. On the recommendation of the Secretary for Mines, the Ministry of Labour has decided to set up a Court of Inquiry, under the Industrial Courts Act, 1919, into the wages questions involved. A further announcement will be made giving the full terms of reference and the constitution of the Court. It is understood that representatives of the owners and men will meet next week and formally agree as to the terms on which work will be continued after April 17 (yesterday, the date of termination of the existing agreement) pending the report of the Court."

From the above figures it will be seen that the voters numbered 661,042. This figure is 100,000 less than the total number of members of the Miners' Federation, the membership being 768,060.

The shipyard lock-out throughout the country took effect as from last Saturday morning, since the Southampton shipyard engineers who went out on strike still refused to return to work. The employers expressed to the executive of the various unions concerned their regret that the action on the part of the Southampton men, in spite of the instructions of the union executives, left no alternative but to let the lock-out notices operate. The employers added they were glad to hear that reports from Southampton indicated that some men would resume work on Monday (the 14th inst.) if proper protection were given. They further stated that they were prepared to withdraw the lock-out notices in respect of any trade affected as soon as there was clear evidence of a general resumption of work by members of that trade at Southampton. Representatives of the Southampton men called on Mr. F. Bramley, secretary of the General Council of the Trades Union Congress, and on Labour Members at the House of Commons, but were told that they could not be helped in what was now a question of discipline between the trade unions and rebellious members. A few Southampton men have returned to work; the great majority, however, remain on strike. It is announced that several unions, including the Shipwrights' Society and the Amalgamated Society of Woodworkers, have expelled their Southampton members. The latter have threatened to form a local shipyard union in opposition to the national ones. The Southampton members of the Amalgamated Engineering Union have decided to continue on strike and have asked for the institution of a Court of Inquiry. After consultation with the chairman and secretary of the Shipbuilding Trades Federation, Mr. Purcell, chairman, and Mr. F. Bramley, secretary of the General Council of the Trades Union Congress, proceeded to Southampton on Tuesday to give the dispute their consideration on the spot. The Mauretania has proceeded from Southampton to Cherbourg. Last Tuesday the Southampton strikers held a meeting and passed the following resolution:—"That an immediate resumption of work be agreed to on condition of (*a*) an immediate conference with the employers to negotiate for the purpose of securing uniformity between the Southampton and London rates and conditions of employment; (*b*) each union to submit a statement indicating the readjustment necessary to bring the Southampton rates and conditions up to the London standard." These terms, at the time of going to press, were being considered by the executive committees of the unions.

The negotiating committees of the employers' and operatives' sections of the Wages and Conditions Council met in London last Friday to consider the demand made by the building trade operatives for an increase in wages of 2*d.* per hour. No agreement was arrived at. It is reported that the employers did not respond to the demand, but offered modifications of the agreement now in force, with a view to the improvement of local conditions.

The six following unions, the Amalgamated Engineering Union, the National Foundry Workers' Union, the United Operatiye Plumbers' Society, the Boilermakers' Society, the Electrical Trades Union and the National Society of Coppersmiths, involving about 350,000 skilled men, have combined together to demand a general advance of 20*s.* per week on present skilled wages rates, and 10*s.* per week on the unskilled. A report is current to the effect that the Belfast members of the Amalgamated Engineering Union decided last Saturday to tender notices to cease work in support of a demand "for the restoration of 10*s.* per week in the cost of living war bonus, plus an extra 10*s.* per week to bring wages into line with the present cost of living." They appointed a deputation to discuss the point with the employers within seven days.

A meeting of the executive committees of the organisations comprising the National Association of Unions in the Textile Trade, was held in Bradford last Saturday, when the following resolution was passed:—

"(1) That an application be made to the employers, members of the National Wool (and Allied) Textile Industrial Council, for an advance on base rates of 10 per cent.

"(2) That all cost of living wages be paid on the same percentage basis, in accordance with the figure issued in the 'Ministry of Labour Gazette,' and that the clauses which provide for a maximum cost of living wage to be paid be and are hereby abolished.

"(3) That the cost of living wages be fixed and determined by the figure issued in the 'Ministry of Labour Gazette' of May, August, November and February.

"(4) That the Secretary prepare a scale of wages for males under 21 years of age and females under 18 years of age, who are not now covered by a scheduled rate of wages, and an application be made for such scale to apply to the operatives employed in the manufacturing and spinning sections of the industry."

The resolution involves about 200,000 operatives.

The fifty-second annual report to the last meeting night in December, 1923, issued by the United Patternmakers' Association, shows a total membership of 11,968, a net income of 53,577*l.*, and a net expenditure of 42,608*l.* for the year. The actual balance of funds was 33,489*l.*, exclusive of the political fund balance of 356*l.*, being 2*l.* 16*s.* per member on December 31.

The new Unemployment Insurance (No. 2) Bill, issued last week, applies to boys and girls between the ages of 14 and 16, who are to be insured against unemployment on becoming employed in an insured trade, on and after October 6 next. The memorandum on the Bill states that under the existing law no person under the age of 16 is insurable. The weekly rate of benefit for boys under 16 is to be 5*s.* and for girls 4*s.* The weekly rate of contribution for the young people between the ages of 14 and 16 is to be 4½*d.* for boys and 4*d.* for girls during the deficiency period, the employer's contribution being 5*d.* and 4½*d.* respectively. After the end of the deficiency period, the contribution for boys between the ages of 14 and 18 is to be 3*d.* both from employer and employed; 2*d.* is to be paid by the girls and 2½*d.* by their employers.

The eighteenth annual report, for 1923, issued by the Skilled Employment and Apprenticeship Association, states that during the year 320 boys and 449 girls have been placed in suitable occupations, nearly the same total as last year, but a considerably higher proportion of boys. The report adds that a very serious feature of the present continued slackness of trade is the loss of skilled men due to their emigration to the Colonies and the United States. While in some trades the employers' federations are insisting that their members shall keep up their full quota of apprentices, in others the employers are unwilling to bind themselves, owing to the uncertain position and the rather antiquated state of apprenticeship law, and are only willing to take learners who are not indentured. In most trades, also, the Trade Unions, by local agreements, limit the number of apprentices in proportion to the journeymen. It is open to doubt whether in a very few years, even under the present slackness of trade, the supply of craftsmen will be found sufficient for the country's needs, while in the event of a trade revival the nation will certainly find itself short of skilled artisans.

FARADAY HOUSE ELECTRICAL ENGINEERING COLLEGE.—Subsequent to the Entrance Scholarship Examination held at Faraday House Electrical Engineering College on the 8th, 9th and 10th inst., six awards were made.

THE "PYRO" RADIATION PYROMETER.

THE useful and convenient type of pyrometer which we illustrate on page 494 has recently been placed upon the market by the Bowen Instrument Company, 9, Newton-road, Leeds, and is sold under the trade name "Pyro." It is of the radiation type, so that it is not suitable for measuring temperatures below 500 deg. C., but for the higher temperatures, up to about 2,000 deg. C., employed in metallurgical processes and in many other industrial operations, the pyrometer we are referring to appears to have numerous applications. It is very easily portable, weighing only 25 oz. and measuring 7 in. long by 4⅛ in. in diameter, and a particularly important characteristic of the instrument is that it is completely self-contained, requiring no batteries or other accessory apparatus.

The external appearance of the instrument is well shown in Fig. 1, while Fig. 2 shows it with the casing removed, so that the essential parts can be seen. The design and construction of the instrument, however, can be most easily followed by examining the longitudinal section reproduced in Fig. 3. As will be seen from this illustration, the body consists of a cylindrical portion, which is constructed of aluminium, and has an axial extension of smaller diameter at each end. In the extension on the right of Fig. 3 is mounted a lens or object glass, while the extension on the left of the illustration carries an eyepiece. The function of the lens, which is made of a special glass having low-absorptive properties for heat rays, is to focus an image of the hot body, of which the temperature is to be measured, on to a blackened absorbing disc. To this disc the hot junction of a small thermocouple is soldered, and the whole is enclosed in an evacuated glass bulb, resembling a battery lamp, except that the usual sealing grip is located in the cap. Fig. 4 shows the construction of the thermocouple bulb on a larger scale. The two leads from the thermocouple are connected to a sensitive millivoltmeter of the moving-coil type, which is mounted in the body of the instrument, as shown in Figs. 2 and 3, and the deflection of the needle of the millivoltmeter by the electromotive force set up in the thermocouple when the image of the hot body falls upon it is a measure of the temperature of the latter. The scale of the millivoltmeter is, of course, graduated to read the temperature directly. In the instrument illustrated in Fig. 1, one of the scales is graduated to read temperatures ranging from 700 deg. C. to 1,400 deg. C., and a second scale is provided for the range 1,300 deg. C. to 2,000 deg. C. When it is desired to use this second scale, a diaphragm is placed over the objective to cut off a certain definite proportion of the radiant heat, and thus to extend the range of the instrument. Other ranges than those mentioned can, of course, be provided within the limits stated above.

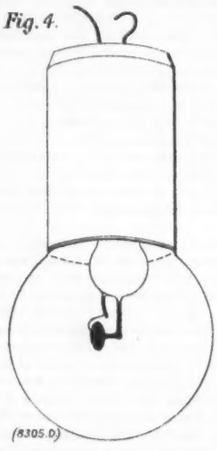
An important advantage possessed by pyrometers of the radiation type, is that they are used at some distance from the furnace, and are, therefore, not exposed to very high temperatures or to the destructive action of the furnace gases. On the other hand, there is a limiting distance between the furnace and the instrument, and if this is exceeded, the temperature readings obtained will be inaccurate. In the standard "Pyro" instrument, the distance factor is 24, which indicates that the distance from the furnace opening to the instrument must not exceed 24 times the diameter of the opening; the furnace opening, however, should not be less than 1½ in. to 2 in. in diameter. If the instrument is used at any point within the limiting distance, the makers state, the temperature measurements are reliable to within 1 per cent. of the full scale reading. In practice, the instrument is sighted on the interior of the furnace, or on an object in the furnace, through either an open door or a sight hole. The observer looking through the eyepiece sees the furnace opening and part of its surroundings, together with the thermocouple, which appears as a black disc in the centre of the field of vision. If the distance, indicated by D_2 in Fig. 5, is too great, the view through the eyepiece will appear as shown in the shaded circle in the lower part of the illustration, in which the thermocouple disc extends beyond the image of the furnace opening indicated by the white rectangular portion of the diagram. By decreasing the distance between the furnace opening and the object glass to D_1, however, the image of the former can be made to cover the thermocouple disc completely, as shown in the shaded circle in the upper part of Fig. 5, and the readings obtained at this, or at any smaller, distance will be reliable.

No focussing is required if the instrument is used within the correct distance limit, the only precaution necessary being to ensure that the image of the furnace opening completely covers the thermocouple disc. For an actual temperature measurement the observer holds the pyrometer to his eye with the object glass pointing towards the furnace opening, and, observing the sighting conditions outlined above, presses the

button shown on the right of the instrument. While the button is depressed, the clamp of the milli-voltm eter needle is released, and the needle is free to take up a position corresponding to the temperature, which it does in about 2 seconds owing to the very low heat capacity of the thermocouple, and absorbing disc. Its motion, however, is quite dead beat, and by releasing the button the needle is clamped in the position it has taken up, so that the reading can be retained until another is required. This is obviously a useful feature when the instrument has to be employed in hot or dark places, since as soon as the required temperature has been taken the instrument can be removed to a more convenient locality for the purpose of recording the reading.

The pyrometers are calibrated by the manufacturers for black-body radiation conditions which are practically obtained in most industrial furnaces, but which do not hold in the case of hot bodies, such as ingots, blooms or small tools, exposed in the open atmosphere after withdrawal from a furnace. Specially calibrated instruments for work of the latter class can, however, be supplied or a scale of approximate corrections can be provided for use with a pyrometer which has been calibrated for black-body conditions. The means employed by the makers for calibration purposes include the adjustment of the aperture shown in contact with the lens in Fig. 3, and of the position of a disc of smoked glass, having a central opening, located near the thermocouple bulb as shown in the section, Fig. 3, and also in Fig. 2. The thermocouple and the opening in the smoked glass screen can both be adjusted so that they lie accurately in the optical axis of the instrument, and the smoked glass screen can be further adjusted in a longitudinal direction to control the cone angle of the heat rays refracted through the lens. The object of the screen is to prevent any scattered rays from reaching the thermocouple, but its longitudinal movement also affects the distance factor of the instrument. The last-mentioned characteristic, however, is mainly dependent upon the diameter of the absorbing

Fig. 4.



disc of the thermocouple. It is possible for special purposes to make the factor as high as 40, although this is unnecessary for ordinary industrial requirements. Further calibration of the pyrometer can be effected by adjustment of the electrical circuit in the usual manner to control the sensitivity of the milli-voltmeter.

Fig. 6 illustrates the law of the Pyro pyrometer in comparison with the Stephan-Boltzmann law which states that radiation from a black body varies as the fourth power of the absolute temperature of the body. In this diagram ordinary pyrometer temperatures are plotted as abscissæ to a fourth-power scale of absolute temperatures, while electromotive forces set up by the thermocouple are plotted as ordinates. It will be seen that the milli-volts developed closely follow the fourth-power law over the temperature range 600 deg. to 1,300 deg. C., but that the law is departed from at higher temperatures. The probable reason for this is that the lens absorbs a small and fairly constant proportion of energy radiated in the red part of the spectrum at moderate temperatures but absorbs greater proportions at higher temperatures when the hot body emits white light. The actual temperature scale of the instrument, which results from the superposition upon each other of the fourth-power law, the absorption effect of the lens, the law of the thermocouple and that of the millivoltmeter, is fairly uniform, as can be seen in Fig. 1, and it can be read to within about 5 deg. throughout the whole range.

The portable instruments, to which our description has been confined, are supplied in a wooden carrying

THE "PYRO" RADIATION PYROMETER.

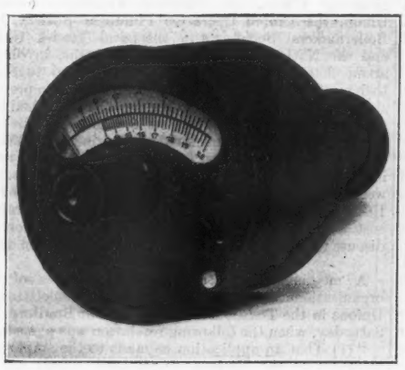


FIG. 1.

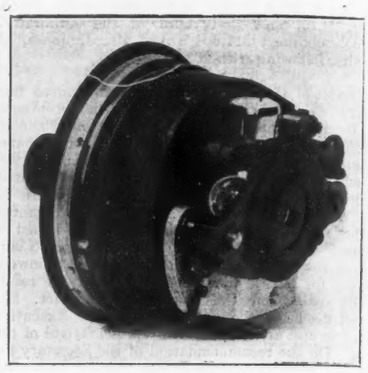


FIG. 2.

Fig. 3.

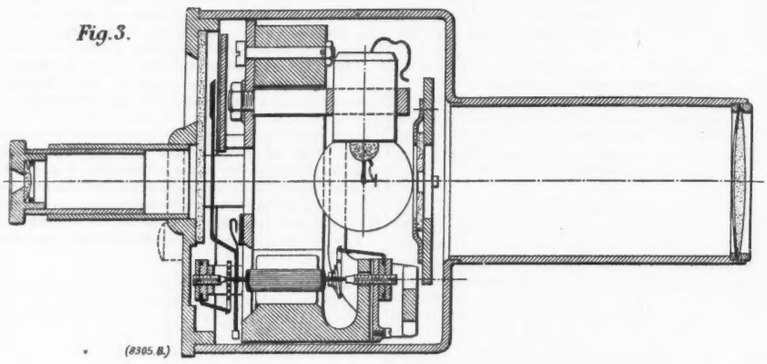
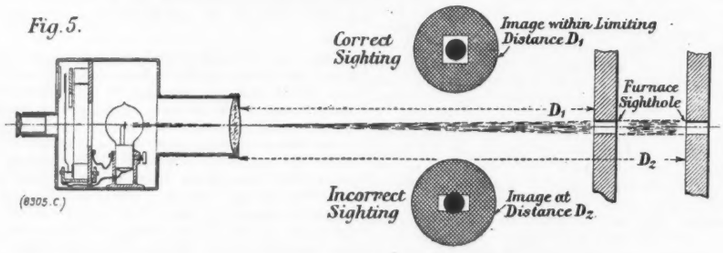
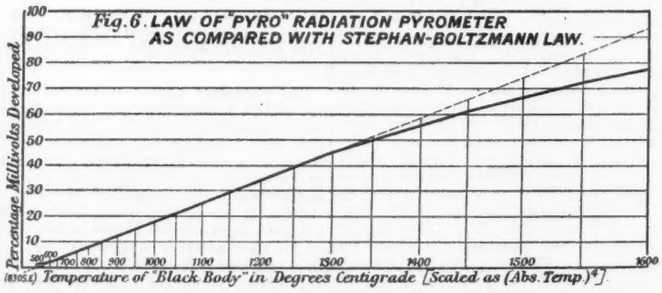


Fig. 5.





case, and they can be used without removing them from the case, since the latter is provided with hinged openings at each end. These instruments can also be mounted on a light collapsible tripod or on a stand with a heavy cast-iron base, the latter form of mounting being suitable for use where frequent intermittent readings of the temperature of a particular furnace have to be taken. A pyrometer operating on the principle described above can, however, be supplied to give continuous indications or chart records of furnace temperatures. For this purpose the optical system and the thermocouple bulb are mounted in a tube which is permanently installed in a fixed position near the furnace and electrically connected to an indicator or recorder fixed in any convenient position. The sighting arrangement adopted, of course, depends upon the type of furnace with which the instrument is to be used, but one method employed is to mount the pyrometer on a swivelling bracket at a suitable distance from the furnace wall and sight it on to the inner closed end of a refractory tube built into the wall and extending into the body of the furnace. If the pyrometer tube has to be installed in an extremely hot position, it can be enclosed in a casing through which air or water is circulated for cooling purposes. It will be obvious that with the distant-reading instruments, it is possible, by the use of a suitable switch, to connect a number of different pyrometers in turn to a single indicator, and, by using a multiple recorder or recorders, to obtain continuous temperature records from several furnaces or from different points in the same furnace.

THE CLERE MECHANICAL SHOVEL.

CONSTRUCTED BY THE WELLMAN SMITH OWEN ENGINEERING CORPORATION, LIMITED, ENGINEERS, LONDON.

Fig. 1.

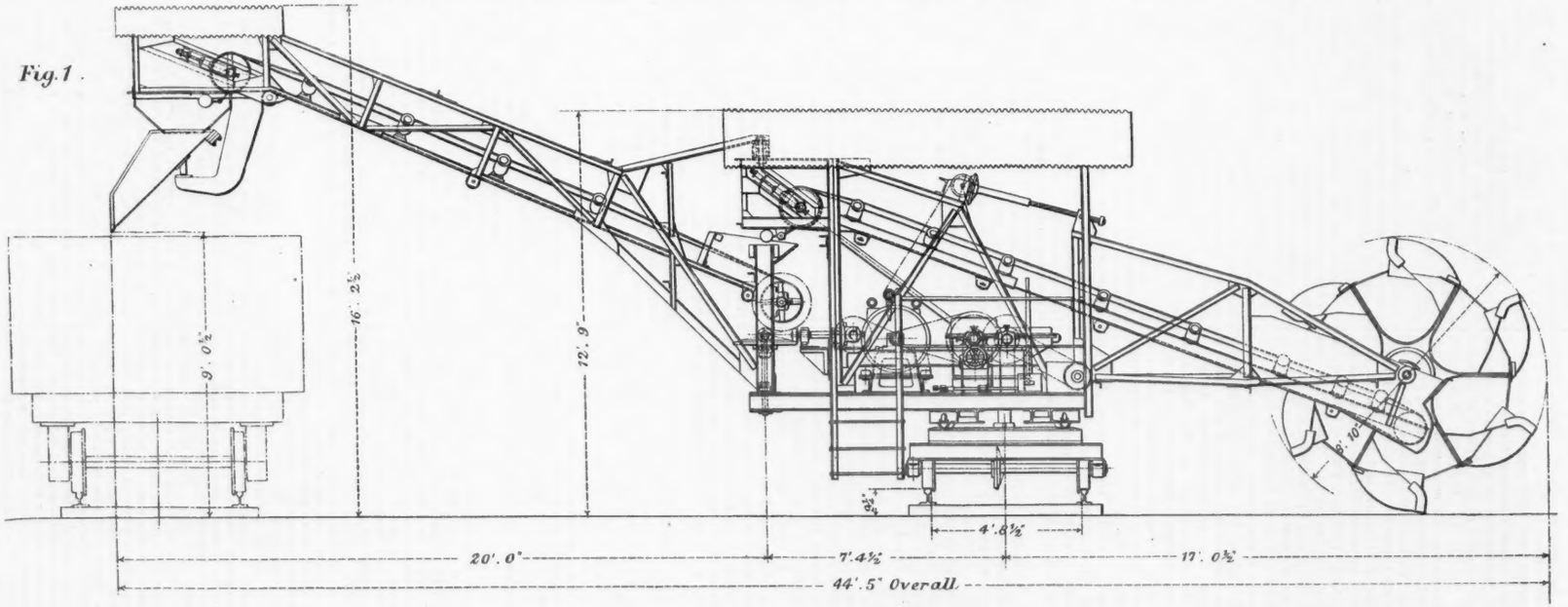
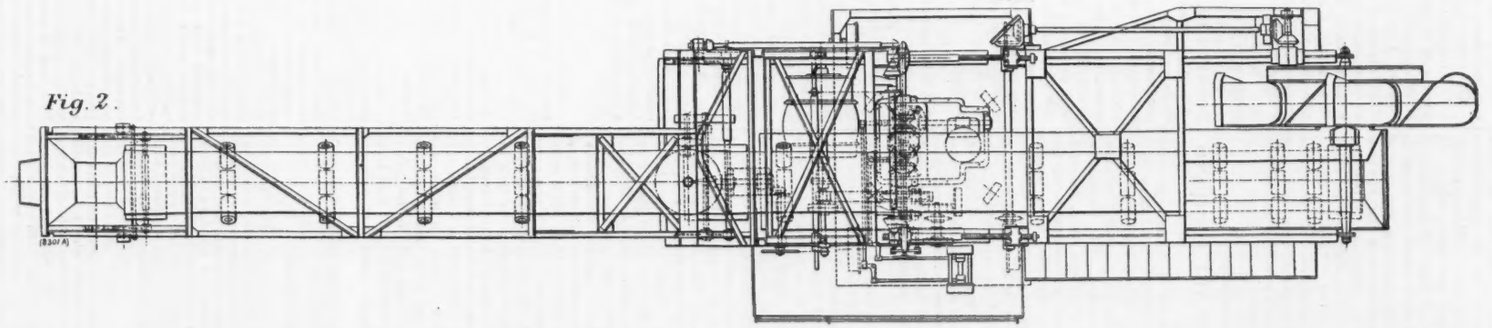


Fig. 2.



THE CLERE MECHANICAL SHOVEL.

A MACHINE designed for excavation work as a rapid and continuous process is illustrated above and on page 498. This machine was designed by the makers, The Wellman Smith Owen Engineering Corporation, Limited, of 36, Kingsway, London, W.C.2, to eliminate the waste of time in slewing, hoisting and depositing the load which is common to machines of the bucket and grab type. It consists essentially of a rotary cutter and a pair of conveyors, the first of which is embodied in the main frame of the machine, while the other, which receives the material from the first, is pivoted to the general structure and can be swung round into suitable positions to fill the trucks.

The outstanding feature of the Clère shovel is the digging wheel which is seen at the end of the machine in the section and plan, Figs. 1 and 2 respectively, as well as at work in Fig. 3. The blades of the digger are curved to enable the material to be cut in whatever position the machine is set to work, and the buckets are constructed of such a shape that the material is made to slide continuously towards the discharging edge. Ejection commences when the bucket arrives a little above the axis of rotation, and is completed before the pouring edge of the bucket has passed the edge of the chute, through which the material is fed on to the belt of the conveyor. The excavating wheel thus serves the double purpose of digging and belt feeding. Instead of the load being thrown over the back of the wheel, it may be seen from the illustrations that it is discharged to one side and in a gradual way as the wheel revolves. Teeth may be fitted on the cutting edges of the buckets to deal with very heavy ground. The whole structure may be revolved upon its undercarriage, and the excavating portion may be raised or lowered to permit the shovel to work above or below the ground on which the track is laid and in line with the track, in trenches alongside or at the side at suitable angles. The material, after it is raised through the main frame of the plant, is deposited on to the other conveyor, which is pivoted to the platform frame. This conveyor can be turned into any suitable position for the deposit of the cuttings into trucks.

An electric motor is mounted on the floor of the platform and motion is taken from it to give the lengthwise travel, the slewing of the upper portion, the driving of the excavating wheel and the running of the conveyors. For these purposes the drive is taken to a layshaft. The excavating wheel is driven through a bevel wheel on its shaft from a side shaft (see Fig. 2), which gets its motion through similar bevels from the other side of

the machine by means of a chain and sprocket drive actuated through a gear from the lay shaft. Bevel gears are also used to obtain the drive for the conveyor belts, which are kept tight by means of loaded tightening gear mounted on the bearing carriages for their axles. The machine illustrated has an approximate weight of 11 tons, and is fitted with a 20-h.p. motor. It can give an average output per hour, which, of course, varies with the type of material handled, of about 60 cub. yd. Figs. 3 to 6 show the complete outfit in service and give a clear notion of the class of work it is suited to, while they also show that the provision of slewing for the rear conveyor enables the material to be deposited into trucks on the same track or on one running parallel to it. This mechanical shovel can also be built mounted on caterpillar tracks and driven by a petrol or paraffin engine for use in situations where tracks are not available and electric power cannot be easily obtained.

THE DUPLICATION OF THE PORTLAND VASE.

THE President, Professor W. E. S. Turner, presided at the meeting of the Society of Glass Technology, held in Stourbridge on Wednesday, March 19.

Mr. J. Northwood contributed a paper entitled "*The Art of British Glass Decorators—The Duplication of the Portland Vase.*" The Portland vase, he said, was regarded as the greatest achievement of the ancient glass makers. Up to the time when Josiah Wedgwood borrowed it from the Duke of Portland for the purpose of imitating it in his jasper ware, it was thought to be stone or earthenware, owing to its dull appearance. The vase is composed of two glasses, the inner body or groundwork of a very dark blue transparent glass, and the outer casing of white opal glass out of which the ornament and figures are sculptured. This decoration stands up in relief from the blue ground.

The reproduction of the Portland vase was accomplished by the late Mr. John Northwood, with the aid of his relative, Mr. Philip Pargeter. The casing of the blue body with a uniform outer layer of opaque white was considered at that time as a matter requiring great skill on the part of the glass maker. It was believed that the actual maker of the glass used in this English Portland vase was Daniel Hancock of Wordsley.

Several blanks were selected, and one was found sufficiently good to be taken in hand in 1873, and carried through to completion. The exterior opaque white was slightly acidised by hydrofluoric acid, and the design drawn upon it. Then commenced the hard labour of removing the surplus white glass from round the figures and design, right down to the blue body ground. Extreme care and patience were necessary to chisel out, without mishap, the delicate details of the human form in order to create a true reproduction. Hence, small carving tools were indispensable. As the work progressed through the three years of labour it entailed Mr. Northwood was allowed by the authorities of the British Museum to take his work and place it beside the original for comparison. The vase was very nearly completed when it suddenly cracked, owing probably to a difference in coefficients of expansion of the two glasses. Still, the artist was not discouraged and in 1876 the work was completed. The vase, said Mr. Northwood, was now in the collection of Mr. P. Pargeter, of Stourbridge. It had been suggested that this work should come into national keeping.

The annual general meeting of the society was held in Sheffield on Wednesday, April 16.

BRITISH IRON AND STEEL PRODUCTION.—The National Federation of Iron and Steel Manufacturers states that the production of pig iron in March amounted to 668,600 tons, compared with 612,700 tons in February and 633,600 tons in March, 1923. The number of furnaces in blast at the end of March was 194, a net decrease of eight compared with February. The output of steel ingots and castings in March amounted to 825,200 tons, compared with 767,600 tons in February and 802,500 tons in March, 1923.

ELECTRICAL TRADER.—To meet the growing necessity for spreading information on British electrical manufactures, a monthly magazine with the title, *Electrical Trader*, has been brought out. The number we have before us is an attractive publication, with many good features. In the introduction the purpose of the promoters is specified as an endeavour "to create and quicken interest in British electrical products, in the full consciousness that they bear the seal of good design and honest workmanship." In comparison with many other countries the use of electricity in Britain has been much smaller in extent than its merits warrant, and we must therefore welcome any endeavour towards the greater extension of knowledge of what can be achieved with it in the home and the industrial works, which it is the aim of our contemporary to supply. The magazine is sold at one shilling, and is published from St. Stephen's House, Westminster.

THE ROYAL METEOROLOGICAL SOCIETY.

THE usual monthly meeting of this society was held on Wednesday, April 9, at the society's rooms, 49, Cromwell Road, South Kensington, Dr. C. Chree, F.R.S., vice-president, in the chair.

The following papers were read and discussed :—

1. "*Glaisher Stand versus Stevenson Screen. A comparison of 40 years' observations of maximum and minimum temperature as recorded in both screens at Camden Square, London,*" by I. D. Margary, M.A.—The observations of maximum and minimum temperature as recorded in the Stevenson screen at Camden Square, London, have been worked up for comparison with those in the Glaisher stand for the forty years 1881-1920, and the values of D (max.) and D (min.) = S-G (Stevenson-Glaisher) investigated. D (max.) shows a very regular seasonal variation from $-1{\cdot}3$ deg. in July to $+0{\cdot}5$ deg. in December. The values are positive ($S > G$) in November to February, and negative ($S < G$) in April to September. This effect is closely parallel to, but does not seem dependent upon, the change of maximum temperature. D (min.) shows little variation throughout the year, and the values are nearly always positive ($S > G$). Until 1905 it averaged $+0{\cdot}8$ deg., but owing, probably, to a rearrangement of the instruments in the Stevenson screen the value then changed abruptly to $+1{\cdot}3$ deg. Northerly winds seem to cause abnormal values of both D (max.) and D (min.), apparently by depressing the Glaisher readings. No relation between D and other elements can be traced. Daily values of D are very irregular, but the monthly values are reasonably constant, and provide a means for converting Glaisher records for comparison with the normal Stevenson readings.

2. "*A Lens for Whole Sky Photographs,*" by Robin Hill, Biochemical Laboratory, Cambridge.—The paper dealt with the representation of a view of 180 deg. within the limits of a photographic plate. Such a view of the aerial world, of necessity distorted, is seen by a fish. This was first photographed by R. W. Wood, who used a pinhole camera filled with water. The same effect can be accomplished by using a lens suitably placed in relation to a stop; a concave surface was found to give the best result. A system of three uncemented lenses, rapid enough for cloud photography, was described which gave a nearly equidistant projection over the whole 180 deg., zenith distances, therefore, being represented by proportional lengths on the photograph. It is likely that a comparatively rapid objective can be produced on similar lines. The production of stereoscopic views of the whole sky in relation to the recording of cloud heights was dealt with, together with a method of converting the distorted representation into a series of undistorted photographs.

ITALIAN NAVAL CONSTRUCTION.—Admiral Thaon di Reval's programme of light cruiser construction does not appear to have taken its final shape. It is reported, however, that the cruisers will all be of the 10,000-ton class, and will carry 8-in. guns of the Schneider design, which will fire projectiles weighing rather more than 200 lb. These guns will be mounted in pairs, and be placed in turrets. Both the turrets and the ammunition hoists will be worked electrically. The charges and the projectiles are sent up to the gun positions by separate hoists.

CARBON MONOXIDE SELF-RESCUERS.—Approval of a new type of safety device, designed as a means of escape for persons accidentally caught in mine or other atmospheres containing carbon monoxide, has been given by the United States Department of the Interior, through the Bureau of Mines, to the "M.S.A. Self-Rescuer," manufactured by the Mine Safety Appliances Company, of Pittsburgh, Pa., under the provisions of Schedule 14A of the Bureau of Mines, which outlines the procedure for establishing a list of permissible gas masks. The self-rescuer consists of a pocket size canister with mouthpiece directly attached, filled with granular fused calcium chloride and granular hoolamite (mixture of special copper oxide and manganese dioxide), which causes carbon monoxide in air to unite with the oxygen at ordinary temperatures, forming harmless carbon dioxide. Cotton filters for removing smoke are also included in the canister. The self-rescuer and a nose clip for closing the nostrils are enclosed in a hermetically sealed brass case to prevent deterioration until used. The weight complete is about 1 lb. 5 oz. The small size permits it to be carried in the pocket or on the belt; for the latter purpose a metal belt loop is attached to the case. Carbon monoxide self-rescuers may enable miners to escape from atmospheres containing carbon monoxide in mines following fires or explosions. They may also safeguard workers in industries above ground where carbon monoxide may be encountered, such as around blast furnaces, in metallurgical operations, or in the chemical industries. The self-rescuer is approved only for self-rescue from carbon monoxide. The Bureau of Mines does not recommend its use as a substitute for carbon monoxide gas masks having large canisters designed to protect persons who are called upon voluntarily to meet carbon monoxide in the course of their work. The approval rather is limited to self-rescue by persons who may be accidentally caught by carbon monoxide.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Huge Salvage Task.—The work shortly to be commenced by Messrs. Cox and Danks, of Sheffield and London, of raising the sunken German fleet at Scapa Flow marks the biggest salvage task ever attempted. Thirty thousand pounds worth of machinery and an ex-German floating dock are to be employed at the outset. It is hoped within the next three weeks to raise a torpedo boat, and before Christmas to bring to the surface the battle cruiser Hindenburg, which lies in 66 ft. of water. The complete undertaking of salvaging 2¼ million tons of sunken vessels will occupy eight or nine years.

Iron and Steel.—While from the standpoint of production the position improves week by week and unemployment correspondingly diminishes, manufacturers continue to experience great difficulty in financing operations, mainly because of the necessity for taking contracts at exceptionally cut rates in international competition, and also because of the heavy burden of rates, taxes and other standing charges which unduly hamper real revival. A reflex of the difficulties encountered is seen in the fact that this week a receiver has been appointed to act for the debenture holders of a large Sheffield steel-making concern. Orders for basic steel are not being renewed at the rate at which they are expiring, though promise of better business is held out by the fact that, owing to recent advances, Continental prices have been brought virtually to the British level. Should this continue, it is expected that users will place their new requirements with home producers. Buying of pig iron and hematites is similarly restricted, though the market for bar iron has substantially strengthened under the influence of the recent accession of locomotive work. The increased output reported at departments engaged in the manufacture of axles, tyres, wheels and springs is fully maintained, with here and there a still further expansion. Buffer springs are particularly active. The automobile industry is also finding a good deal of work locally. Tramway steel is another improving section, not only on provincial account, but in several foreign markets where guaranteed quality outweighs the consideration of currency differences. Mixed conditions prevail in the lighter trades, though improved demands are reported for certain classes of tools from South America and some of the British colonies. Garden implements, quarry tools, road-making appliances, files and saws all show increased activity.

South Yorkshire Coal Trade.—The insistent demand for increased deliveries on contract account is responsible for an almost entire absence of supplies for open market disposal. Shipments are still somewhat on the light side, but British railway companies and other home users are readily absorbing all they can secure. Colliery operations are still subject to transport limitations. Cobbles and nuts are firm at unchanged rates, while the scarcity of slacks is enhanced by stocking operations at the pits. There is no surplus of house coal, despite a marked diminution of the demand, due to warmer weather. Coke is unaltered. Quotations: Best branch handpicked, 36*s.* to 39*s.*; Barnsley best silkstone, 34*s.* to 36*s.*; Derbyshire best brights, 31*s.* to 35*s.*; Derbyshire best house, 27*s.* to 29*s.*; Derbyshire best large nuts, 27*s.* to 28*s.*; Derbyshire best small nuts, 20*s.* 6*d.* to 23*s.*; Yorkshire hards, 27*s.* to 30*s.*; Derbyshire hards, 25*s.* to 28*s.*; rough slacks, 12*s.* 6*d.* to 15*s.* 6*d.*; nutty slacks, 12*s.* to 14*s.*; smalls, 8*s.* to 10*s.*

SCREENING OF ILLINOIS COAL.—Coal-mine operators in Illinois have requested the Department of the Interior to authorise the Central District Experiment Station of the Bureau of Mines, at Urbana, Ill., to conduct a study of the problem of reducing the proportion of screenings in the coal mined in that State. This is said to have become a very acute problem with Illinois coal operators. The market for Illinois coal is largely one for coal to be used in heating dwelling-houses. The demand, therefore, is for the larger sizes. This problem of screens has been growing more intense since the plan of paying the miners for "run-of-mine" tonnage rather than for "screen coal" tonnage came into existence. While there are other factors involved, one of the most important causes of this excess of screenings, according to the Bureau of Mines, is the method employed in the use of explosives.

CONTRACTS.—The Hodroyd Coal Company have placed orders for complete electro-pneumatic decking plant for their 2-deck cages at the pit top of their Brierley Colliery, and for decking plant comprising two rams, &c., for their single-deck cages at their Ferry Moor Colliery, with the Westinghouse Brake and Saxby Signal Company, Limited.—Messrs. Vickers, Limited, Barrow-in-Furness, have secured the order for a second unit for the Holborough Cement Works, Halling, Kent, comprising a large rotary kiln and cooler, and all subsidiary machinery, including electrical equipment manufactured by the Metropolitan-Vickers Electrical Company, Limited. They are at present erecting the first unit of the plant, and this work is now nearing completion. The most modern practice for the manufacture of cement is embodied in the works, and each unit will have an annual capacity of 50,000 tons.—Messrs. Meldrums Limited, Timperley, near Manchester, state that in the first three months of the current year forty-three boilers of various types, for various industries, have been fitted with their forced draught furnaces, or mechanical stokers; they have also supplied fifteen refuse destructors; thirteen sets of portable steam disinfectors and numerous pieces of apparatus for chemical plants.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—Exports of coal from the principal ports in South Wales in March amounted to 2,260,322 tons, valued at 2,858,151*l.*, or 25*s.* 3*d.* per ton. Compared with February, when the shipments reached the lowest point touched for thirteen months, the volume of trade in March showed an increase of 261,717 tons, and the yield was advanced by 328,463*l.*, although the average price per ton was reduced by 1*d.* Shipments from Cardiff were increased from 1,230,104 tons to 1,435,798 tons, but the average at 25*s.* 6*d.* was lowered by 2*d.* per ton, while the exports from Port Talbot were increased from 177,107 tons to 180,690 tons and the average at 22*s.* 4*d.* reduced by 3*d.* at 22*s.* 4*d.*, and the shipments from Swansea were advanced from 169,137 tons to 239,083 tons and the average price at 25*s.* 10*d.* increased by 1*s.* 6*d.* per ton. On the other hand, exports from Newport were reduced from 422,257 tons to 404,751 tons and the average price at 25*s.* 8*d.* by 1*d.* per ton. The total quantity of small coal shipped was increased from 646,176 tons to 769,231 tons, but the average price secured at 20*s.* was 2½*d.* less than in February; shipments of through coal were, however, reduced from 80,979 tons to 66,537 tons and the average price at 21*s.* 2*d.* by 7*d.* per ton. Exports of large coal were, however, increased from 1,271,450 tons to 1,424,554 tons, but the average price at 28*s.* 4*d.* was lower by 4*d.* per ton. The price secured for Welsh coal shipped in March at 25*s.* 3*d.* per ton was 5*d.* more than that secured in the corresponding month of last year. In view of the holidays and the fact that operators generally had covered their requirements for the immediate future, new business has been comparatively quiet. The export demand has eased off with the increasing deliveries of German reparation coals to Italy through Holland, and heavier Continental purchases of American coal, in view of the possibility of a national miners' strike in this country. Ireland consumers, too, are stocked for the next couple of months, and here, again, the pressure for supplies has eased off. In the circumstances, market prices have developed a weaker tendency, the best Admiralty large coals being obtainable at 30*s.* to 31*s.* per ton f.o.b., with Monmouthshires from 27*s.* to 31*s.* and smalls from 16*s.* to 22*s.*, according to quality.

NATIONAL INSTITUTE OF INDUSTRIAL PSYCHOLOGY.—The Rt. Hon. the Earl of Balfour has accepted the position of President of this Institute. He is the first President to be appointed and will preside at the Institute Dinner to be held at the Victoria Hotel, Northumberland Avenue, W.C., on Thursday, the 29th inst., when the Rt. Hon. Tom Shaw, Minister of Labour, and Sir Hugh Bell, Bart., will be among the guests of the Institute and will speak.

ENGINEERING WORK, BUENOS AYRES.—The Commercial Secretary at Buenos Ayres reports that the Argentine Ministry of Public Works are inviting tenders for the supply of pumps and material required for converting vessels of that department to burn fuel oil. Tenders will be received in Buenos Aires up to 3 p.m. on May 22. Further particulars may be obtained on application to the Department of Overseas Trade, 35, Old Queen Street, London, S.W.1, quoting reference 9497/FL/EC (2).

COLLIERIES ON THE GREAT WESTERN RAILWAY.—The G.W.R. Company are issuing a list of the collieries adjacent to stations on their extensive system in South Wales and Monmouthshire, North Wales, the Forest of Dean, Shropshire, South Staffordshire, Somersetshire, &c. The book also gives particulars of the invoicing stations for each pit, and the class of coal produced. It contains two excellent maps—one showing the position of each coalfield in relation to the Great Western system as a whole, and the other indicating the position of the coal invoicing stations in the Monmouthshire and South Wales District. Other useful information includes a list of the collieries at which washery plants are installed; foundry coke producers and patent fuel manufacturers, besides general data on the facilities for shipment of coal at Great Western ports and others to which the company have direct access. The book is of a convenient size, neatly bound in cloth covers, and should prove of use to members of the coal trade and large consumers of fuel, who can obtain a copy upon application to the Mineral Traffic Manager, Paddington Station, London, W. 2.

COAL-DUST FUEL.—After more than two years' trials the Steelworks Van der Zypen und Wissen, in Rhenish Prussia, declare themselves satisfied with the experience they have gained with dust fuel in seven of their steam-hammer works and six of their rolling mills. The fuel is essentially briquette waste, containing on an average nearly 20 per cent. of moisture, but sometimes wet with rain; in the latter case more dry coal dust or brown coal dust is mixed with the briquette dust than is done in ordinary practice. The furnace dimensions were left unchanged, but a combustion chamber for dust fuel was arranged on the grate. The fire-bricks used contain 42·5 per cent. of alumina. The adaptation of the furnace took four days' work. At first there was a good deal of melting of the brick arches; finally the bricks lasted more than eight months, though temperatures of 1,600 deg. C. (2,900 deg. F.) were observed. The flue dust gave no trouble at all. Experiments are also being made (*Stahl und Eisen*, March 13) with dust fuel in an open-hearth furnace which had been constructed for gas fuel; there the results have so far been discouraging, the temperatures of 2,000 deg. C. changing the silica bricks into stalactites a yard in length after seven heats.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Business in Cleveland pig-iron is not so active as it has been, but there is still a fair amount doing, and the outlook is not discouraging. Moderate home sales are reported, and quite good Continental inquiries are still circulating. A drop of half-a-crown in the price of No. 3 made by one of the principal firms of producers, reducing the ruling quality to 92*s.* 6*d.*, was unexpected. Other makers have been slow to follow the movement, which, however, has disturbed the market. Quotations for other qualities of Cleveland iron are now difficult to fix. No. 1 may be put at 97*s.* 6*d.* to 100*s.*; No. 4 Foundry at about 92*s.*; and No. 4 forge, 91*s.* 6*d.*

Hematite.—A rather more hopeful feeling is noticeable in the east coast hematite branch. A quiet, steady business is passing and expansion of demand after the holidays is anticipated. Nos. 1, 2, and 3 stand at 99*s.* f.o.t., and buyers report they can also place f.o.b. orders at that figure, though some makers are disinclined to sell for shipment at the price named. No. 1 is put at 100*s.*

Foreign Ore.—Dealers in imported ore report absolute stagnation. Consumers are off the market, being well placed as regards supplies, and the recognised quotations on the basis of best rubio at 24*s.* c.i.f. Tees are purely nominal.

Blast-furnace Coke.—Quotations for Durham blast-furnace coke are irregular. Customers claim they can satisfy requirements at round about 30*s.* for good medium qualities, but there are sellers who ask up to 32*s.* 6*d.* delivered to local consumers.

Manufactured Iron and Steel.—There is not much new to report concerning finished iron and steel. Generally, sales are still slow, but in one or two branches inquiries are stated to be slightly better. Among the principal market quotations are:—Common iron bars, 12*l.* 10*s.*; iron rivets, 14*l.*; packing (parallel), 9*l.*; packing (tapered), 12*l.*; steel billets (soft), 9*l.*; steel billets (medium), 10*l.*; steel billets (hard), 10*l.* 5*s.*; steel boiler plates, 13*l.* 10*s.*; steel ship, bridge, and tank plates, 10*l.* 5*s.*; steel angles, 10*l.*; steel joists, 10*l.*; heavy sections of steel rails, 9*l.*; fish plates, 13*l.*; black sheets, 13*l.* 10*s.*; and galvanised corrugated sheets, 17*l.* 10*s.*

THE NEW MIAMI FORT POWER STATION.—The Columbia Power Company, a subsidiary of the Columbia Gas and Electric Company, have contracted with the Fuller-Lehigh Company for complete pulverized coal preparation, conveying and burning equipment for eight 1,500 h.p. Babcock and Wilcox boilers to be installed at the new Miami Fort Power Station. The equipment will comprise six 57 in. Fuller-Lehigh screen type pulverizers, gear driven. Two 6 ft. 6 in. × 50 ft. Fuller-Kinyon pumps will convey the coal from the pulverizers to weigh bins and 10 in. pumps will distribute the fuel from the weigh bins to the boiler bins. Each boiler will be equipped with five Fuller Triplex feeders driven by variable speed motors. The boilers are of hollow wall design with no water screens; they are equipped with economisers and air heaters. The operating pressure of the station will be 575 lb., and the total steam temperature approximately 725 deg. F. The generating equipment for the first unit will be two 40,000 kw. reheater turbines, the plant being extended as the demand for power expands.

SPONGE IRON.—A new process for the production of sponge iron has been developed by the United States Department of the Interior, in co-operation with the University of Washington. Sponge iron, owing to its porous structure and consequent exposure of an extremely large surface of metallic iron, is especially adaptable to the precipitation of copper, lead and other metals from their solution. The development of a process by which sponge iron may be made cheaply from iron ore and low-grade coal and afterwards converted into iron and steel products by treatment in the electric furnace would be of especial economic importance to the Pacific Coast region of the United States, a territory remote from the larger iron and steel producing centres, but endowed with cheap electric energy. The possibility of making sponge iron and converting it to steel without passing through the stage of pig-iron production has been suggested from time to time. The production of steel from sponge iron has theoretical advantages over present standard methods. Moreover, the production of both steel and pig iron from sponge iron has economic advantages in certain localities. The fact that both electric melting and sponge-iron production processes can be conducted economically on a small scale makes such a proposed process particularly advantageous in communities that do not consume much iron or steel. There is some hope that sponge iron can be briquetted and melted in the open-hearth steel furnace without too much oxidation. If this could be accomplished a much larger field of usefulness would be opened up for cheap sponge iron. In the new process referred to almost any type of iron ore is satisfactory for the production of sponge iron. The process consists in passing a mixture of iron ore and coal through a rotating kiln heated at one end to a temperature sufficient to convert iron oxide to metallic iron, discharging, cooling and separating the sponge iron from the residual coke and siliceous material in a magnetic separator. Details of these experiments are given in Serial 2578, by Clyde E. Williams, Edward P. Barrett, and Bernard M. Larsen, which may be obtained from the Department of the Interior, Bureau of Mines, Washington, D.C.

NOTICES OF MEETINGS.

THE INSTITUTION OF LOCOMOTIVE ENGINEERS (LONDON).—Thursday, April 24, at 7 p.m., at the Engineers' Club, Coventry Street, W. 1. "Terminal Station Working," by Mr. J. Pelham Maitland.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, April 25, at 7.30 p.m., at 39, Victoria-street, S.W. 1. Lecturette, "Aluminium Electrical Conductors for Overhead Power Transmission," by H. G. Williams.

THE INSTITUTION OF ELECTRICAL ENGINEERS: SCOTTISH CENTRE.—Friday, April 25, at 7.30 p.m., at the Technical Institute, Dundee. "The Characteristics of a D.C. Series Machine Self-Excited by Rectified Current for the Purposes of Regenerative Control," by Mr. R. D. Archibald.

THE USE OF OXYGEN IN BLAST FURNACES.—The Bureau of Mines, Washington, has sponsored, through an appointed advisory committee, an investigation of the use of oxygen or oxygenated air in metallurgical processes. The bureau's committee has now developed plans for experimentally determining the effects of oxygen-enriched air on the operation of the blast furnace, and has recommended that these plans be put into effect as the first step of an extended research on the general applicability of oxygen in metallurgy. It is hoped that funds can be provided for testing the committee's findings at the bureau's experimental blast furnace in Minneapolis. After a critical review of the facts, the committee concluded that, in the present method of smelting iron, it will be practical to increase the oxygen content of the blast 21 per cent. to 31 per cent. and that this enriched blast, when fed to the furnace cold, will increase the production of the furnace by 18 per cent. and decrease costs by 6·7 per cent. The study has convinced the committee that with the application of oxygen to present blast-furnace practice the cost of production will be decreased; the output per furnace will be increased; closer chemical control will increase the uniformity of the product; cheaper materials, ore of lower iron content and coke higher in ash, can be used; and, it is believed that the sulphur content of the iron can be reduced.

THE RELATIVE IMPORTANCE OF ACCIDENTS IN COAL MINES.—The widespread attention given to the fatalities from explosions has resulted in the common supposition that gas and coal-dust explosions form the main hazards of mining. The United States Bureau of Mines finds that if the deaths from falls of roof and coal could be eliminated, the number of miners killed in America would be reduced to about one half. Deaths occur singly or in pairs in the dark recesses of the mine when a slab of slate falls or when coal at the face or in a pillar rolls over and crushes a worker. The deaths from roof falls aggregated 900 during 1922. The fact that this number is less than the total for several preceding years is due to thousands of men having been idle for several months during the bituminous coal strike. The larger part of the responsibility for decreasing this class of accidents may fairly be placed on the miners themselves. Most of the falls occur at the working places, and the miners there are better able to observe the conditions under which they work and to tell when the roof should be taken down or additional props put up than is anyone else. For the 11-year period that ended with 1922, 47·84 per cent. of all fatalities were due to falls of roof and coal, 16·85 per cent. were caused by mine cars and locomotives, 11·25 per cent. by gas and coal-dust explosions, 6·04 per cent. by explosives, and 3·47 per cent. by electricity. During this period 25,975 men were killed in coal mines. Approximately 90 per cent. of all the deaths occurred underground, 2·29 per cent. were from shaft accidents, and the remainder, 7·59 per cent., occurred on the surface.

DIRECTORY OF SHIPOWNERS, SHIPBUILDERS AND MARINE ENGINEERS.—This directory, which forms one of the most useful reference books for persons connected with, or interested in, the shipping and shipbuilding industries, has now reached its twenty-second year of publication, and the 1924 edition, which has just been issued, well maintains the standard reached in the earlier volumes. The general arrangement of the work remains the same as usual, the first section giving information regarding the Admiralty and other Government Departments, the classification societies, &c. Following this is a list of shipowners in all parts of the world, giving, in each case, their addresses and the names of the principal officials, as well as particulars of the services operated and vessels owned. The next section gives a list of shipbuilders, marine engineers and dry-dock owners, with particulars of their officials, plant and annual outputs, while the remaining sections are occupied with lists of consulting marine engineers and naval architects, and trade, technical and educational organisations, &c. Although the entries in the various sections are arranged in alphabetical order, a carefully compiled general index to the contents is included, and, in addition to this, there is an index to the names arranged geographically, a personal index of the names of officials and another index to the names of vessels. These indexes, which include over 24,000 entries, greatly facilitate the use of the book, and constitute a feature which might well be copied in other works of reference. The book, which is compiled under the direction of the Editor of *Shipbuilding and Shipping Record*, is published by the Directory Publishing Company, Limited, 33, Tothill Street, Westminster, S.W.1, and its price is 20*s.* net.

THE CLERE MECHANICAL SHOVEL.

CONSTRUCTED BY THE WELLMAN SMITH OWEN ENGINEERING CORPORATION, LIMITED, ENGINEERS, LONDON.

(*For Description, see Page* 495.)

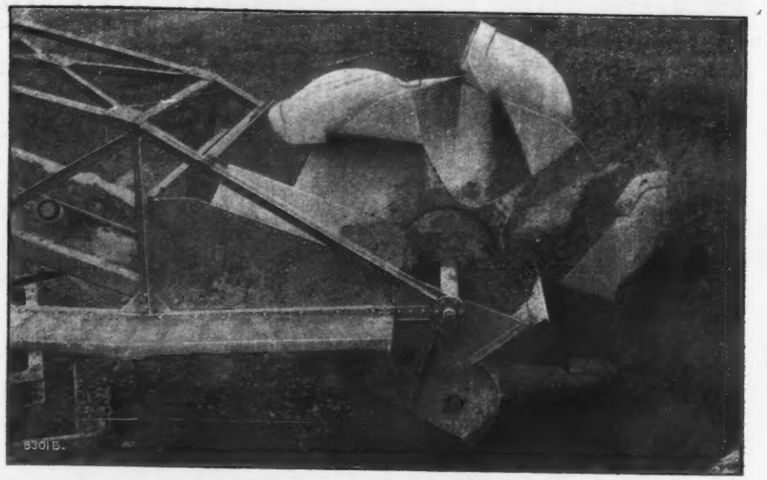


FIG. 3. THE EXCAVATING WHEEL.

FIG. 4. THE SHOVEL EXCAVATING AND DELIVERING TO TRUCK.

FIG. 5. SHOVEL OPERATING IN A RAILWAY CUTTING.

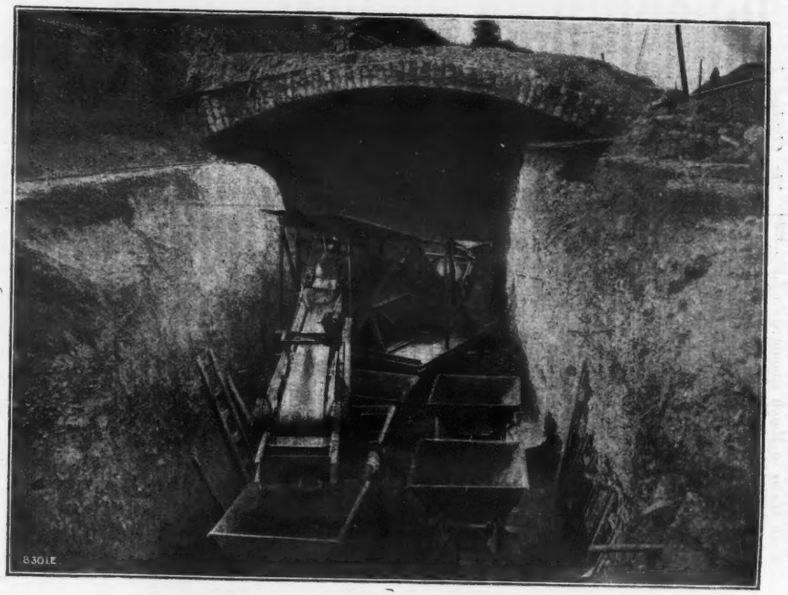


FIG. 6. REAR OF MACHINE SHOWING DELIVERY SYSTEM.

FIG. 5. PRINTING IN A RAILWAY CUTTING.

FIG. 6. REAR OF MACHINE SHOWING DELIVERY SYSTEM.

THE FRENCH TORPEDO BOAT

CONSTRUCTED BY THE CHANTIERS ATELIER

(For Description see Page

1 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 Metres.

5 0 5 10 15 20 25 30 35 40 45 50 Feet.

Fig. 2.

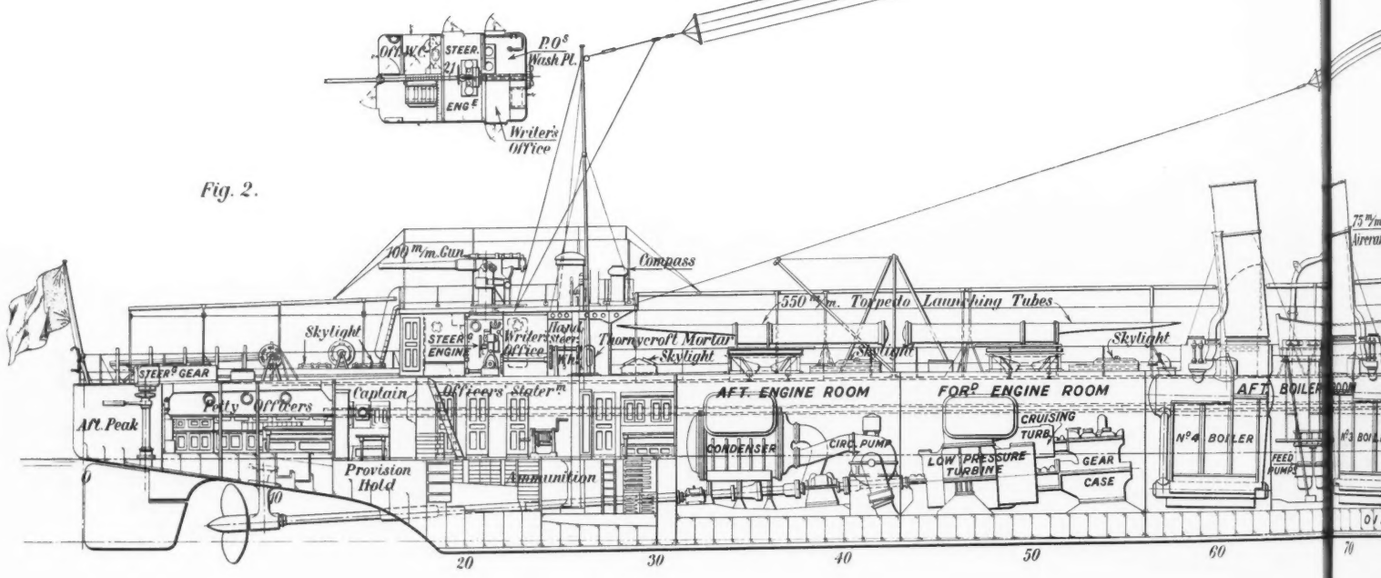


Fig. 3.

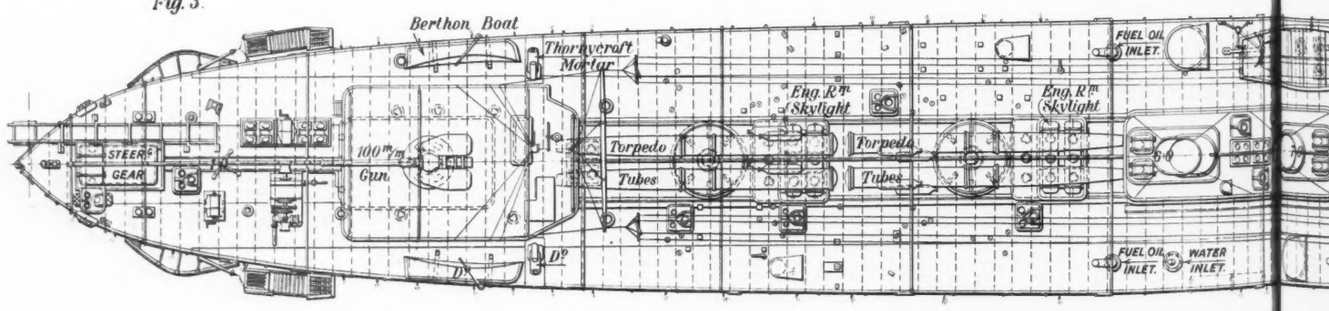
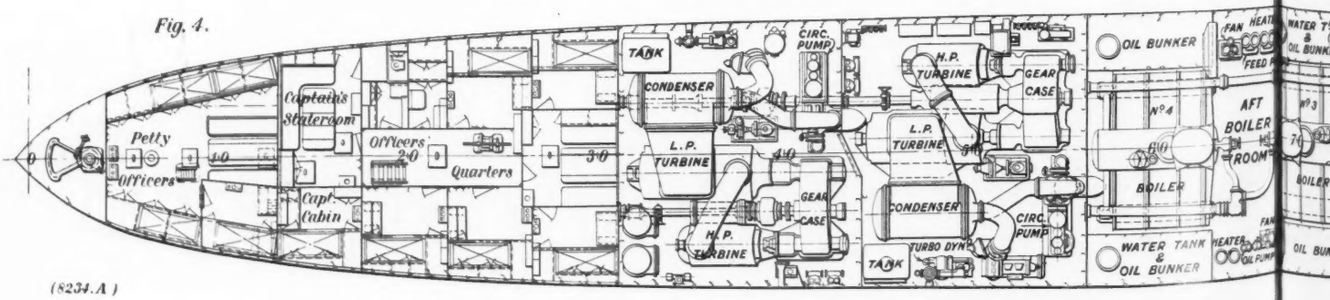


Fig. 4.



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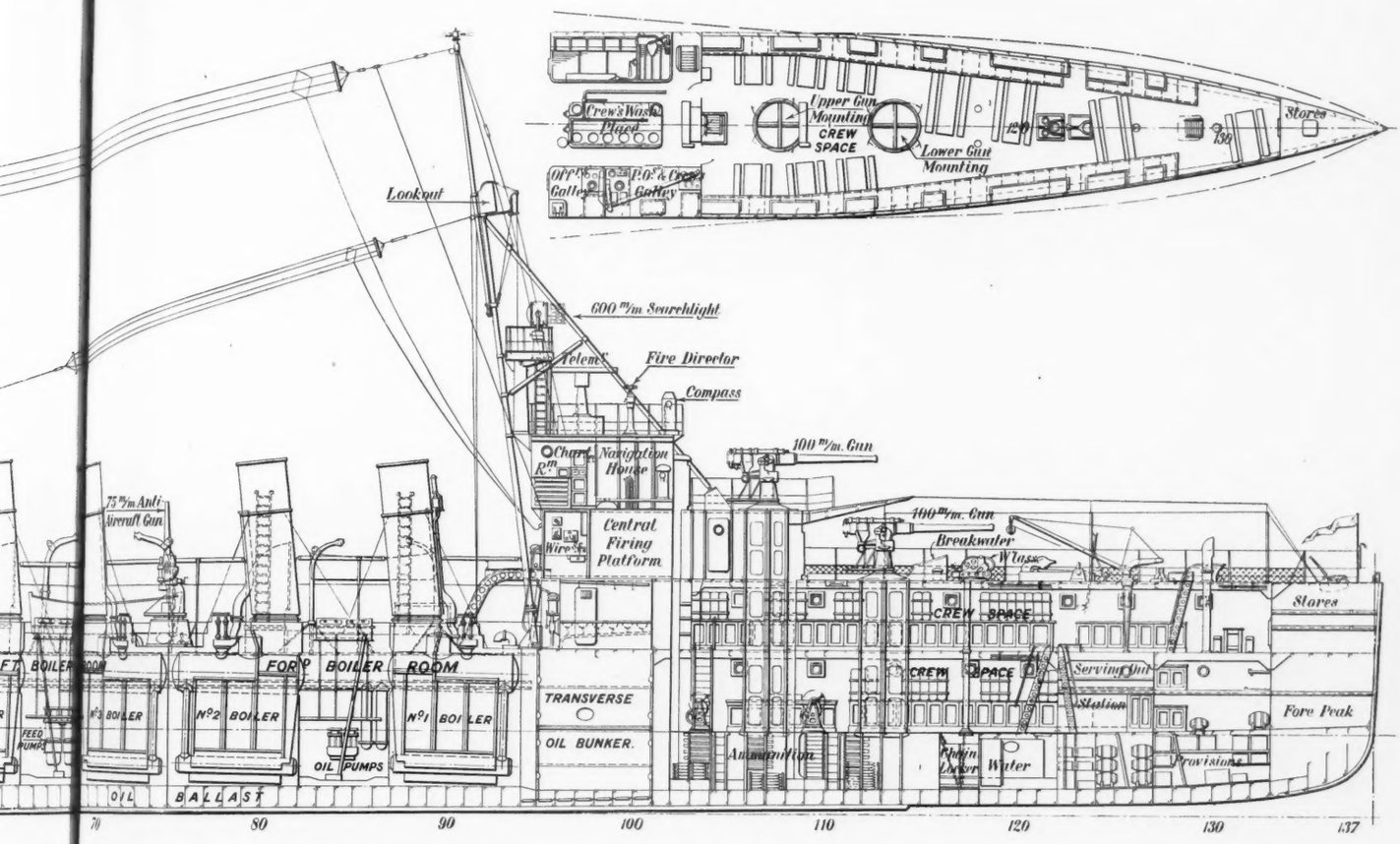
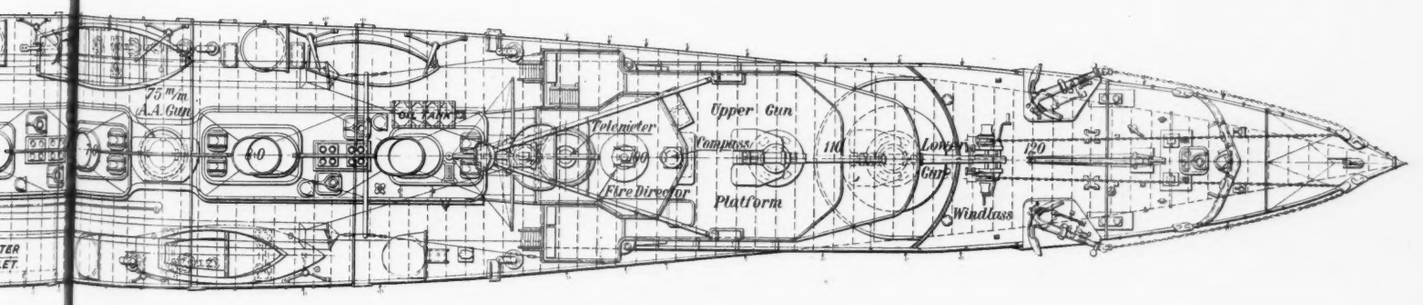
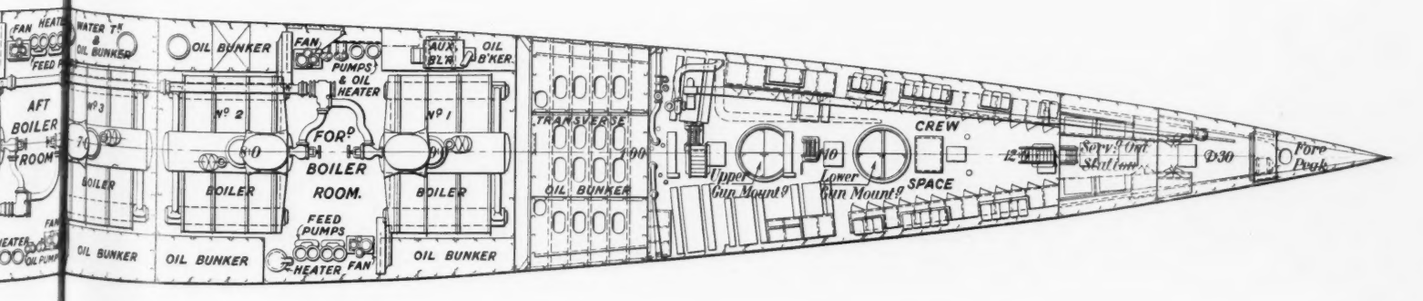
PEDO OAT "ENSEIGNE GABOLDE."

CHANTIERS ATELIERS AUGUSTIN NORMAND, HAVRE.

(For Descrip see Page 483.)







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TIME FOR RECEIPT OF ADVERTISEMENTS.

Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity of going to press early with a portion of the edition, alterations for standing advertisements should be received 10 days previous to the day of publication.

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THE BRITISH EMPIRE EXHIBITION.

Next week's issue of ENGINEERING will contain a special supplement dealing with the evolution, history and organisation of the British Empire Exhibition, and giving illustrations and descriptive articles of many of the exhibits. There will be 21 Plates. The price will remain the same as usual.

ENGINEERING.

FRIDAY, APRIL 18, 1924.

INDUSTRY AND DEMOCRACY.

THE historian of the future, in summarising the civilisation of the past fifty years, will consider this period as specially notable for two great lines of development. The extraordinary increase in knowledge and the consequent command over natural forces, brought about possibilities of comfort, leisure and luxury unthought of by earlier generations, and simultaneously with this change in the conditions of the population there came about a corresponding alteration in the ideas as to the political and social organisation under which the community could best flourish. That these two matters are closely related cannot be doubted. The emancipation of thought from the dogmatism of earlier periods made its effect felt in every aspect of life, and the same spirit which so successfully questioned material difficulties inspired a belief that human nature was capable of directing itself wisely and enjoying the prosperity which knowledge had made possible. The history of past civilisations which have risen and perished fortunately never damps the optimism which is the spring of progress; but it has its lessons, the chief of which is that internal decay and lack of discipline are more to be feared than any external destructive forces.

The rise of Great Britain as an industrial nation has taken place along the only lines which are conceivable. The skill of individual craftsmen has been co-ordinated by others having the faculty of organisation and the enterprise to undertake the responsibility for projects too great to be carried out independently. The provision of the necessary tools and apparatus for work on a large scale, and the payment of the workers during the period of its completion, were provided for out of the savings of the thrifty, who denied themselves in order to save, and lent the necessary money on condition that they shared in the anticipated profits of the enterprise. The system, on the whole, proved satisfactory, and under it a vast amount of wealth was created. The community in general was much better off than before, and the average workman or labourer could enjoy housing, food, books and other amenities of life which were unattainable by the wealthiest in the land a few generations previously. The accumulation of wealth, or in other words, the provision of still more facilities for production, resulted in the development of what has been called the factory system, although it equally made possible and encouraged public services on a large scale which have little or no connection with factories. It has therefore come about that the community is supplied with necessities and comforts of a civilised existence by large organisations of specialised workers, each group concerned only in the production of a single commodity.

It is difficult to imagine any other arrangement under which efficient production, which is the basis of civilisation, could be secured, but the system has in itself elements of instability that have recently been much in evidence in this and other countries. The facility of inter-communication have made it possible for the whole of the workers in any industry to combine and suddenly withhold their labour, as a means of coercing the rest of the community into granting them some alleged rights or special privileges which they may claim. If they are not numerous or important enough to get their way easily, some more essential group can usually be found to withhold their own labour, in "sympathy," as we have seen on several occasions recently. This kind of thing is the absolute negation of every democratic principle.

It is profiteering in the necessities of others quite as flagrantly as the "cornering" of foodstuffs, and it is just as reprehensible. The fact that it is done by hundreds or thousands of men acting in unison does not differentiate it from the act of an individual, except that it is vastly more difficult to deal with. To deprecate conduct of the kind to which we refer is entirely consistent with admitting the right of any man, or any body of men, to refuse to work under conditions which they find to be intolerable. The right to strike is not at issue, but only the abuse of the power of combination in order to enforce against the community terms of which the strikers have constituted themselves the sole judges.

It was hoped that with the growing power of the trades unions there would develop a sense of responsibility in their leaders which would make for industrial peace. The fanatic or the demagogue are fortunately not representative of the bulk of our trade union officials, and to that extent the confidence has been justified. But the honesty, wisdom and self-restraint frequently shown by the best of the men's leaders is all too frequently negatived by impetuous action of the rank and file, usually led by men with little to lose and with notoriety, at least, to gain by fomenting disaffection with the leaders. The lack of discipline within the ranks of the unions themselves makes their official undertakings almost valueless, and consequently the most carefully drawn up and definite agreements as to wages or conditions of labour are no security against a whole industry being thrown into confusion practically without warning. The fact that orders are almost impossible to obtain under such conditions, that distress is brought upon thousands of other workers who have no part in the dispute, and that in many cases suffering is caused to the public, seems to have no weight at all. The repeal of the Act of 1906, by which Parliament put trade unions above the law, so that neither their officials nor their funds could be touched for unlawful acts, would not meet the case of the "unofficial" strikes. The officials in such cases are powerless, and what they need is support and not chastisement. Nevertheless, if ever this country is to carry on the industry necessary to enable its working population to live with a reasonable standard of comfort, some greater measure of stability must be ensured, and that quickly.

The problem of avoiding strikes and look-outs,

official and otherwise, has been the subject of an immense amount of thought, but most of those who have studied the subject have confined themselves to endeavouring to devise some kind of industrial machinery which would enable agreement to be arrived at before a strike or lock-out took place rather than afterwards. While such work is very commendable it does nothing to prevent those "lightning" or unofficial or "sympathetic" strikes which are a greater curse to industry, and therefore to those who live by it, than the formal battles of opposed economic forces, disastrous as the latter no doubt are. Strikes in the public services, such as those connected with the supply of water, light or transportation, or with sewage or refuse disposal, are particularly reprehensible, whether of the "lightning" variety or otherwise. They are directed at the helpless community, with the idea of extorting terms by force rather than securing fair treatment by constitutional means, and if democratic government is to continue possible it will have to find some way of dealing with what has become a public menace. Within the last year we have actually heard of a trade union bestowing medals upon men for their share in putting a portion of London in darkness, and the threats of interference with electricity supply have been too numerous to keep count of.

Any constructive policy, on the part of those responsible for public order, with the object of maintaining essential services, must be based upon the last resource of democracy, namely, the use of the power of the community to protect its own rights. The essence of democratic government is that the wish of the majority of the citizens shall prevail, and it is undoubtedly their wish that they shall be allowed to carry on their lawful occupations unhindered by any interruptions of public services by some small fraction of the population. No one would wish to take away the right of men to cease work if dissatisfied with the conditions of service, and even if the public service strikes were made illegal it would be quite impracticable to conduct legal proceedings against or to punish, if found guilty, the thousands of men who might strike nevertheless. Continuity of service is not to be secured by such means. The community fortunately always contains abundance of citizens with the necessary technical ability and the public spirit to maintain any public service which is threatened by the defection of those whose business it is to run it. To ensure them adequate protection while they are serving the public is the least the community can do, and the more truly democratic the Government the more sternly will it resist any attempt by the few to interfere with the business or pleasure of the many. It should be clearly understood that any body of men who abandon any necessary service either before a properly qualified tribunal has adjudicated on their complaint, or because judgment has not been given in their favour, are false to the democratic doctrines which they profess. The whole strength of the State should, if necessary, be employed to vindicate these doctrines in a practical way, namely, by protecting the majority from the consequences of the misconduct of the few. The men who insist on the right to strike for themselves must be made to concede to others the right to work, and especially where any public service is at stake the tyranny of the few over the many should not be tolerated.

SMALL STEAM POWER PLANTS.

UNDER the economic pressure of the high cost of fuel and the stimulus of competition from the internal combustion engine, considerable advances have recently been made in the over-all efficiency of large steam plants, but in the case of the small steam engine and boiler little progress has been recorded for many years. Apart from the work of a few individuals, who have not always profited thereby, it might almost be said that progress with the small steam engine ceased with the introduction of compounding, while in many applications the state of affairs is even more primitive, and designs show no appreciable advance from the middle of last century.

Large power stations or ocean liners consuming their thousands of tons of fuel per year may be more spectacular, but it is probable that the fuel consumption of small steam plants of all descriptions forms a much larger proportion of the whole consumption for power purposes in this country than is commonly realised. Therefore the low efficiency of such plants is a matter of importance, and one that might well receive attention from engineers and users of power. In addition to thousands of small steam vessels, there are many steam plants in factories, laundries, and similar work; while steam cranes exist in large numbers and are notoriously wasteful of fuel.

Unlike electric power, a small steam plant may be entirely self-contained, and may burn almost any combustible material obtainable in the district, a boiler being much more catholic in its tastes than any form of oil or gas engine. This power of adapting its appetite to its habitat is most valuable, and is possessed by the steam plant alone among prime movers, thus rendering it possible to utilise steam power where nothing else would be so convenient, or even possible. Moreover, the ability of a steam engine to exert full torque at low or zero speed gives it, for some purposes, an enormous advantage over the internal combustion engine and also over some forms of electric motor. Although a steam plant may be in bad condition and leaking at every joint and gland, it may be depended upon to keep working until the last gasp, thus contrasting favourably with oil or gas engines, which may be put out of action by some defect quite trifling in itself yet sufficient to stop the engine.

On the debit side of the account are several heavy items, of which not the least is deterioration of the boiler, which may become very serious under certain circumstances. Apart from actual repairs, the upkeep of a boiler by way of scaling, and so forth, may be entrusted to fairly unskilled hands, while the repairs to the engine will certainly cost less, spread over a period of years, than the corresponding figure for an oil or gas engine; on balance the totals will usually be against the steam plant. Where the outfit is small enough to be run by one man acting as driver and fireman, as may be taken to be the case of the plants under consideration, there will be little or no difference in the cost of labour; if anything, the internal combustion engine will here be at a disadvantage, unless a regular whole-time attendant can be dispensed with.

Owing to the widely different conditions of operation, it is impossible to suggest average values for the fuel consumption of many steam plants, the worst conditions probably being met with in portable cranes, ferries and other jobs where the actual working time is short and intermittent, the stand-by losses then swamping the consumption for power purposes. Unquestionably, the small steam engine is at a great disadvantage when compared with the oil or gas engine in respect of fuel consumption when measuring in terms of B.Th.U. per horse-power hour, but the position may not be so bad when considered in terms of cost and convenience of supply. Perhaps the extreme case would be that of a colliery where slack could be burnt at practically no expenditure, whereas fuel oil might cost £5 per ton, or oil for use in engines perhaps considerably more than even that figure. Somewhat similar conditions exist in ome districts abroad, where wood may be the cheapest fuel and oil obtainable only with difficulty, or where the waste from a factory can be burnt at no expense beyond local transport. Even in such circumstances as those just cited, however, the need for studying the efficiency of the plant is great, if the steam engine is to prove a satisfactory investment.

Small steam vessels are very numerous, and despite the advantages of the oil engine are still being built in considerable numbers. A by no means negligible proportion of these have simple or non-condensing engines and boilers of crude design, but the majority have compound surface-condensing engines and marine type boilers working at from 60 lb. to 120 lb. per sq. in. pressure, coal being the almost universal fuel. Speaking generally, it should not prove economical to build any small steam vessel to-day, yet for certain purposes a really efficient steam plant might be able to compete favourably with the oil engine, the capital cost of which is very great. Intended chiefly for pleasure craft, one or two builders have turned out steam launch machinery with oil-burning boilers that have proved thoroughly satisfactory, but the cost is of the same order as that of oil engines, while the fuel consumption is heavier. Such machinery, however, serves to indicate that it is possible to improve very greatly upon the ordinary run of small marine engines, but it is doubtful if such advanced designs will now ever be adapted to larger or commercial work. One thing is quite certain, that even the simplest of oil engines would be a source of endless trouble if entrusted to the class of "engineers" who handle many of the small steam craft about our coasts and rivers.

Steam auxiliaries in the larger ships are usually wasteful of fuel, the long runs of pipes being responsible for much loss, while the design of the engines themselves is of a very low order. Simple engines taking steam for the whole stroke are quite common, and are almost a necessity for such work as winches, where high starting torque is required. But there is room for improvement in many of the more constantly running auxiliaries, such as lighting, steering, and pumping engines, the direct-acting pump usually being a terrible steam eater. Modern practice in large vessels, of course, tends towards the adoption of electric driving for certain auxiliaries, but the ordinary and old-fashioned steam equipment continues to be used, even in Diesel-engined ships, which have to be provided with a boiler for auxiliary purposes.

Perhaps the highest development of the steam engine and boiler in small sizes is to-day found in the steam wagon, which, in spite of the theoretical advantages of the internal combustion engine, at least holds its own for heavy transport. Steam engineers are, it is to be feared, as a class rather conservative, and the progress made in steam wagons is largely due to the fact that some of these have been designed by men who held no preconceived views on the subject, but brought to bear minds fresh from automobile or other practice. It is rather remarkable that coal and coke continue to be the standard fuels for road work, one objection to the use of the cheaper grades of oil being that of difficulty in starting from cold without a supply of compressed air.

In small factories, mills and laundries there are many steam engines working very inefficiently, but on the other hand there are installations in which steam is used for both heating and the production of power in a very effective manner. If the industrial plant requires high-pressure steam, reciprocating engines or turbines can be run on the discharge from the heating plant, turbines being more effective on low pressures. If, on the other hand, the plant can use steam at low pressure, the engine exhaust may be passed into the heating mains or exhaust steam turbines working with a high vacuum may be utilised. Owing to the smaller cost per horse-power of the engine working at high pressure and to the comparatively small addition to the fuel bill to raise steam to that pressure, there are cases where the simple, non-condensing engine may be a better business proposition than the actually more efficient turbine with its high vacuum condensing plant, although the position would be reversed if it were not for the use of the steam for other purposes in addition to that of power production.

The generation of steam from the waste heat of internal combustion engines offers a tempting field for experiment, and it may certainly be said that matters have now progressed beyond the experimental stage and have arrived at that of practical development. In this connection, the Still engine immediately comes to mind, but there appear to be great possibilities in the use of steam without going to the extreme of working it through the engine cylinders. It is understood that, to mention but one instance, a Clarkson boiler in conjunction with an oil engine has proved very satisfactory, such a combination possessing the advantage that the boiler may be fired on oil when the engine is not running. But in order that such combinations may prove successful, it is essential that the efficiency of the steam side of the plant be as high as possible, and in this respect much existing plant would prove useless for such purposes.

It is not too much to say that a saving of 25 per cent. of the fuel may be effected, by properly lagging

the boiler and other parts with non-heat-conducting material. Conversely, a smaller boiler may be used for the same duty; or, as will generally be found better, the boiler may be worked at a more economical rate. Strangely enough, boilers which are fully exposed to the weather, such as those on portable cranes, are frequently seen devoid of all lagging, as are many in small steam vessels. There can be no doubt that the lagging of such boilers would prove a sound investment; moreover, the lagging should extend to all piping and to the engine cylinders and heads. Some form of feed-water heater can usually be fitted at small expense, and this will be found to effect a further saving of fuel. Moderate superheat of the steam is advantageous also, but is almost unknown in small plants, apart from wagons; it need not be carried far enough to cause trouble with lubrication or gland packings, and the first cost is trifling in relation to the saving effected.

Steam users generally do not realise that all heat radiated from a plant represents fuel wasted, even on the exhaust side of the engine, where an enormous amount of heat is commonly thrown away in the condenser circulating water or directly to the atmosphere. Working the engine to a lower terminal pressure with a view to reducing the latter loss may not be possible, but there are few small steam plants in which considerable economy could not be effected by attention to radiation and other losses on the high-pressure side of the engine.

BRITISH TRADE WITH ITALY.

THE year 1923 was one of notable achievement in Italy by the Mussolini Government. The necessity of balancing the budget having impressed them, they endeavoured to achieve whatever was possible by the introduction of economies in the public services. Examples innumerable might be cited, but the work done in effecting savings in the administration of the railways and the postal system are most conspicuous. Legislative and administrative reforms of an exceptional nature were made during the year in connection with the civil services, public works, insurance, banking, foreign trade, general industry, the transfer of unproductive public services to private enterprise and, indeed, in almost every branch of public life. Great progress must also be reported in the carrying out of these reforms. Such a record of achievement was, of course, only possible under the special powers granted to the Executive, by Parliament and by a Government with a very strong backing in the country. There are many problems still awaiting solution among which the chief are the finding of an outlet for the surplus population and the inadequacy of the national resources in comparison with the capital required to finance the national requirements. There are definite signs of an improved economic position in the re-establishment of the credit of the country to be seen in the stable position of the exchange, the increase of national savings, the rise in value of Italian securities, the decrease of unemployment and the general spirit of discipline and confidence among the people. The Fascista Government when it came into power had to consider whether, in the general interest and to maintain the standard of living, it was better to encourage production or to persecute the capital holder. Nothing can be gained by the latter method and the Government recognised the fact and has therefore concentrated on the increase of production. Revenue has been increased, not by imposing new taxes, but by improving the methods of enforcing the taxes already in existence.

After allowing for the difference of the exchange it is apparent, from the figures given in a "Report on the Commercial, Industrial and Economic Situation in Italy" prepared for the Department of Overseas Trade by Messrs. J. H. Henderson and H. C. A. Carpenter, and sold as one of the regular publications of the Department, that the total volume of trade between Britain and Italy was the same in the year 1922 as in 1913. Italian imports from Great Britain were less than the pre-war figure but the exports were greater. An increase in both imports and exports was shown, however, in the first half of 1923, the latest period for which full detailed returns are yet available. Coal is an important import from this country. In 1913 some 9,397,000 tons of British coal were imported, but that figure showed a reduction to 5,771,000 in 1922. An improvement was again shown in the first half of 1923 when 3,398,000 tons were delivered in place of 2,775,000 tons for the similar period in the previous year. Gas works showed an increased demand and the requirements of glass and ceramic works were also larger. Electricity continues as a formidable competitor to gas, and as a large percentage of electrical energy is now obtained in Italy from water power this acts to the detriment of coal importations. At the close of 1923, notwithstanding the efforts of the British exporters, the tone of the coal and freight market was considerably lower than at the beginning of the year. Coal is a prime necessity and must be obtained at almost any price and therefore the exchange rate does not affect business very much. The stocks are heavier than present requirements, due to accumulations made by speculators during the Ruhr crisis. British coal still keeps the lead in the market since the German reparation coal has not affected industrial needs to any appreciable extent and American coals are practically negligible.

Pig-iron imports showed a fall from 112,556 tons in 1913 to 66,165 tons in 1922, and the diminution continued in 1923. The main features of British import trade other than coal and iron have not appreciably altered since before the war. In the first half of 1923 as compared with the corresponding period in 1922, signs of a revival in trade were manifested and since then there has been an increase in both value and bulk of British imports. Italy looks to France and Great Britain to supply her needs of pig-iron. France, in the first half of the year 1923, had a slight advantage in quantity but the value of the British product was greatly in excess of the French. The steel market, though not normal, showed an improvement in 1923 over the previous year. Purchases are confined to immediate necessities, but it is pleasing to note that enquiries are increasing. Of high-speed steels and tool steels the consumption is small, and 80 per cent. of the business is done by a single Czecho-Slovakian firm. In steel billets British prices are fairly competitive but some business is lost through quotations being made f.o.b. British ports instead of duty paid Milan. Alloy steel is in demand by the aviation works and for the motor industry. Germany is not at present able to deliver this particular type of steel, the best grades of which are not produced in Italy. British prices for steel files are not competitive and 60 per cent. must be taken off the list prices of high-speed drills before they can compete with local manufactures. There is a large consumption of tinplate in Italy. It is, however, not profitable to import tinplate unless for subsequent re-export, in the form of containers for foodstuffs, in which case there is a Customs drawback. Only the producers of foodstuffs can, however, benefit by the drawback and the importation is limited principally to these customers.

Textile machinery agents report that the year 1923 was the best of any since the war, probably owing to the fact that renewals and repairs cannot be put off any longer. Prospects for the future are fair. The British prices for pumping plant are high and must be reduced by 40 to 50 per cent. to compete on even terms with the local manufactures, which include everything but the largest units. The British firms have, however, shown enterprise in organising demonstrations and by granting Italian terms of credit. Business has been done, but the condition of the market is still far from satisfactory. Germany does a good trade in machine tools but at prices fully 50 per cent. lower than those for British manufactures. With the exception of motor accessories it is becoming increasingly difficult to sell British electrical material in Italy and her needs are mainly supplied by U.S.A., Germany and Switzerland. Generally the Italian buyers are at present overwhelmed with offers and in many cases are able to impose their own terms. There is prevalent a strong national feeling, but those offering the easiest conditions of payment will frequently get business though their prices are high. There is still much criticism in Italy of the harshness of the terms offered by firms in the United Kingdom.

CAUSE OF THE OPPAU EXPLOSION.

ON September 21, 1921, a silo said to contain 4,500 tons of the double salt of ammonium nitrate and ammonium sulphate, used as fertiliser, exploded at the Oppau works of the Badische Anilin und Sodafabrik in territory under French occupation. The iron-brick building, 60 m. by 30 m. by 19 m. high, disappeared entirely and left a crater 10 m. deep, surrounded by a wall of earth, debris and undecomposed salt. The double salt had been considered non-explosive; as it had turned into a very hard cake, it had to be got out of the silo by means of blasting, and blasting agents had been applied thousands of times when the catastrophe occurred. In order to investigate the mysterious explosion the Department of Industrial and Scientific Research obtained in October, 1922, 22 cwt. of the Oppau salt and also of the undecomposed scattered salt and of the blasting agents used. The reports on the investigations conducted at Woolwich and at the Government Laboratory were discussed by the Faraday Society on April 14.

Dealing with the physico-chemical problems, Sir Robert Robertson, F.R.S., President of the Faraday Society, found that the Oppau salt really represented a double salt, possibly also mixed crystals, in the molecular ratio of one sulphate to two nitrates, that it was fairly pure, free from explosive impurities, and also from substances likely to undergo spontaneous decomposition, but that it contained sufficient moisture to harden. The further gravimetric and optical study of ammonium nitrate and ammonium sulphate by Mr. A. G. Francis and Dr. H. Thomas showed that the two salts form a series of compounds characterised by rapid changes in optical—and, therefore, we presume also constitutional—properties. Dr. Godfrey Rotter, Director of Explosive Research, Woolwich, reported on the manifold and very instructive explosion tests made and on their theoretical interpretation. He had failed to make the Oppau salt detonate by shock, by the astralit and perastralit used at Oppau (containing trinitro-toluene, ammonium nitrate and aluminium, also potassium perchlorate) and by other high explosives in bombs, steel tubes and in a gun, placing the initiating charge either at the top or inside the charge. Part of the nitrate had been decomposed leaving the sulphate undecomposed; but that was more marked in mixtures of the two salts than in the Oppau salt, and the explosion had not travelled far into the mass of the double salt, which itself appeared to be non-explosive.

The cause of the explosion therefore remains obscure, and the conclusion drawn from the investigation was summarised by Sir Richard Threlfall in the words that the Board had to choose between three improbabilities: (1) that in spite of the Woolwich and German experiments the double salt was capable of partial detonation under the extreme conditions of confinement in the store; (2) that through some oversight or accident there existed in the store large pockets of ammonium nitrate unmixed with sulphate or mixed with a proportion insufficient to prevent deterioration; (3) that some 50 or 100 tons of high explosive had deliberately been concealed under the store at Oppau. Of these improbabilities the Board considered the second the least extreme. This conclusion was in close agreement with the German report published last month.* One fact unknown to the British investigators was, moreover, mentioned in the German report. The Oppau salt had originally been prepared by mixing the saturated solutions of the two salts; but for some time previous to the explosion the nitrate had been squirted on a conveyor band and the sulphate added by hand. That would increase the

* An abstract of this appeared in the *Chemiker Zeitung*, March 13 and 20. As regards the damage done—559 people were killed and 2,053 buildings destroyed, half of them totally—and for the lessons to be drawn as to the structure of buildings for such works we should refer our readers to a paragraph on the Oppau Explosion on page 191 of our issue of August 10, 1923.

possibility of the formation of pockets of nitrate, which is itself a mild explosive, but might become violent when confined.

The German report is the work of a Reichstag Committee which had been deliberating on the case for two years. One of the points emphasised in it is the possibility of a gradual de-mixing of a mixture of the two salts, especially when the salts are deposited as a fine powder from diluted solutions at higher temperatures, 140 deg. to 150 deg. C., and that many explosives had been considered harmless until found not to be so. The de-mixing was mentioned by Dr. Freeth during the discussion, and Mr. H. T. Tizard, of Oxford, referred to another important point—the huge scale of the explosion. Dr. Rotter had experimented with charges of 250 lb. maximum; but the silo contained thousands of tons. Sir Frederic Nathan supported that argument. He agreed with the English report that it was unlikely that anybody would again try to blast a caked product of this type; but caution was advisable.

NOTES.

Trials of the North British Diesel Engine.

Test bed trials have now been carried out on the new double-acting two-stroke Diesel engine, designed by Mr. J. C. M. Maclagan and constructed by the North British Diesel Engine Works, Limited, of Whiteinch, Glasgow. The details of construction of this interesting departure from the common design are familiar to our readers from a description we gave of the engine last June (see Engineering, vol. cxv, page 794). The engine submitted to test was that which will be installed later in the 9,000-ton cargo vessel Swanley, launched on March 22 by Messrs. Barclay Curle and Co., Limited, of Whiteinch. It has three cylinders of 24½ inches diameter and 44 inches stroke. The trials comprised a non-stop run of nine days at an average load of 1,940 brake horse-power, which was obtained with the engine running at 94 revolutions per minute. The oil used was Anglo-Mexican boiler fuel with a specific gravity of 0·96. The consumption found was 0·448 pounds per brake horse-power, corresponding to about 9¾ tons of oil per day in service. The lubrication oil used during the tests amounted to an average of 11 gallons every 24 hours. An overload test at 2,200 brake horse-power, representing 10 per cent. more than the normal full load was also carried out. Throughout the tests the engine ran with smoothness, regularity and freedom from vibration, the careful balancing of the moving parts having given these desirable characteristics The original design of this purely British engine was dealt with by the designer, Mr. Maclagan, in a paper which he read before the Institution of Engineers and Shipbuilders in Scotland on Tuesday last, when he gave the results of many investigations into the stresses to which the various parts are subjected. Turning moment diagrams were also given in the paper to show the superiority of balance of the moving parts of such a design of double-acting Diesel engine over what was usually obtained with a triple expansion steam engine.

Long-Distance Passenger Locomotive Runs.

In a recent article we gave an account of the movement in the United States tending towards improving the mileage of locomotives by working them through for longer distances than formerly, changing the crews two or three times *en route*. A recent issue of the *Railway Review* of Chicago gives an account of what is believed to be, up till the present, the record of operation of this kind. The service in question is on the Southern Pacific Company's system, and a special class of 4-8-2 type locomotive has been designed and built by the American Locomotive Company to the specification of the General Superintendent of Motor Power, Mr. G. McCormick, to undertake the difficult duty. The distance covered by the regular run is no less than 815 miles without changing locomotives. The schedule speed works out to between 24 and 26 miles per hour with trains of from twelve to fourteen passenger, baggage and mail cars. The run is on the part of the company's service from Los Angeles in California, to El Paso in Texas, passing through the States of Arizona and New Mexico. In this distance a number of stretches of 1, 1·5 and 2 per cent. grades are encountered, the highest point reached being 4,622 ft. above sea-level, and the lowest—203·7 ft. below datum. The greater part of the rise is accomplished in about 200 miles. The engines designed for this traffic each weigh 368,000 lb., of which 246,000 lb. are on the drivers. The two cylinders are 28 in. by 30 in., and the driving wheels 73 in. in diameter. With a boiler pressure of 210 lb., a tractive effort of 67,660 lb. is developed, with booster working. Oil is used for fuel, the boiler having a heating surface of 4,551 sq. ft., of which 350 ft. are in the fire-box and combustion chamber. The superheating surface is 1,162 sq. ft., and the grate area 75·66 sq. ft. The tender is of the cylindrical tank type, carrying 12,000 galls. of water, and 4,000 galls. of oil. It is carried on two 4-wheel trucks. The engines in this service are reported to be doing 12,000 miles per month.

The Building Trades Exhibition at Olympia.

That endeavours are being made to introduce suitable machinery and materials for the reduction of building costs is shown on all sides at the Building Trades Exhibition at Olympia, which was opened by the Right Hon. John Wheatley, M.P., Minister of Health, on Friday, April 11. It will remain open until Saturday, April 26. A great variety of woodworking machinery is exhibited, and the examples chosen are in the main those suitable for use by building contractors rather than by specialising manufacturers. Machine methods in woodworking are essential if the costs of building operations are to be reduced, and it is interesting to see the extent to which the building trade has turned to these processes in these times of high costs. Most of the firms show surfacing machines, turning machines, bench saws, mortising machines and general tools such as any builder might find work for. Other items of interest are the many types of new materials suggested for building, while stone saws and dressing machines are also available for inspection. To facilitate reinforced concrete work tools are exhibited with which to bend the steel members and standard shuttering is shown, such as may be removed for other work once the material has set. One interesting exhibit shows how shuttering for a variety of work may be built up of small components, while another type of shuttering is such that once a section is partly set it may be swung upwards to form another section above that already in place. This is done by wiring the shutters together at the top so that when the concrete is in place and reasonably set, the shutters may be turned upwards using the loops of wire, extending out of the concrete, as hinges. The Ciment Fondu process is well shown by the building up of the structure of the stand. The quick setting properties of this aluminous cement is indicated by the fact that the frames were cast at the site on the Friday and Saturday before the exhibition was opened and were able to take a load on the Monday following. Steel tube scaffolding, conveyors, portable engines for machine driving on the site of the work, cement mixers and many other types of plant contribute to a very good show of the modern appliances used in building. Meetings and conferences are to be held during the run of the exhibition by the various architectural, building and special trades associations.

The Powers of the Electricity Commissioners.

A legal decision of interest to all undertakings concerned with the supply of electricity was given by Mr. Justice Romer on April 14. The Corporation of Ealing, who were the owners of a little electric light station, with a total capacity of only 2,520 kw., wished to increase their supply. They consulted with the Electricity Commissioners, who refused to permit any extension of the plant, and advised them to negotiate for the purchase of current in bulk from one of the larger undertakings. They ultimately came to an agreement with the Borough of Hammersmith, but the arrangement was not one of which the Commissioners could approve. The Ealing Corporation thereupon decided to instal a new 2,000-kw. turbo-alternator in their own station, in place of old plant of 300 kw. capacity, and to charge the expense to revenue account in order to have to avoid borrowing the 20,000*l.* for the purpose. The new set having been installed contrary to their instructions, the Commissioners brought an action to obtain a declaration that the Corporation were not entitled to do what they had done. The Judge interpreted the Electricity Act of 1919 in accordance with common sense, holding that the statute prohibited not only an extension in the size of the works but also an increase in capacity without the Commissioners' consent. The Act was framed to give the Commissioners power to settle schemes of improvement without being hampered by such extensions of existing plants as had been made in this case. The Commissioners did not ask for any injunction against the Corporation, and as the Judge decided that the provision of an entirely new generating set at the cost of 20,000*l.* was an expense properly chargeable to capital and not to revenue, it would appear that the Ealing Corporation has got all it wanted. Nevertheless, the case will do good by making it clear that the Commissioners' powers are effective, and it is likely that municipalities or companies disregarding their orders in future will not escape with as much satisfaction as Ealing. Whether Ealing should have bought a new turbo-alternator or whether it should have purchased a bulk supply is not the point at issue. The Commissioners may have been right or they may have been wrong, but they are the body to whom the public are looking for that systematic development of electricity supply, by which alone cheapness will be secured, and their powers to bring about that development are not to be frustrated by the selfish action of small interests.

THE INSTITUTION OF MECHANICAL ENGINEERS.

An ordinary general meeting of this Institution was held on Friday last, the 11th instant, at 6 p.m., at Storey's Gate, Westminster, Mr. W. H. Patchell, the President, occupying the chair.

Air Consumption and Brake Horse-power in Internal-Combustion Engines.

The formal business of the meeting was followed by the reading of a paper on "The Relationship of Air Consumption to Brake Horse-Power in Internal-Combustion Engines; Road and Flight Tests," by Dr. H. Moss, D.Sc., of the Air Ministry Laboratory, Imperial College of Science and Technology. We reprint this paper in abridged form elsewhere in the present issue.

Mr. J. L. Hodgson said the method described in the paper was, perhaps, the simplest and most perfect available for measuring the flow to an engine in flight. The orifice or Venturi method could be used where bulk was not material, as, for instance, on the ground. In the Venturi method it was necessary to damp out practically all vibrations. Dr. Moss did not need to correct for variations in pressure or temperature, because he measured the weight of air directly; the orifice method measured head, which required to be measured in terms of pressure and temperature of the gas flowing through it. The history of the method given by the author was interesting. In 1909 a patent was taken out by Professor Thomas, who claimed that it was a method of determining the rates of flow of gases, which comprised adding heat at a known rate to a moving current of gas, of a known specific heat, and determining the rise of temperature thereby produced in such gas. This claim was clearly not justified, as the method had been worked out by Professor Callendar twenty years earlier. The method had been applied by Professor Thomas to measurement of large volumes of gas, but was unsatisfactory because it involved heating the gas that passed through the instrument by several degrees, and in the case of large volumes was very expensive. Dr. Moss's method was probably the best possible one for the volumes involved with small engines. The use of Dr. Moss's instrument in water-vapour involved a source of error, as did also actual water in the form of rain or fog, since the heating grid would have to supply a certain

amount of latent heat to the water before it could actually heat the air.

Mr. Hodgson then proceeded to discuss the effect of using a receiver to damp out vibrations and further the effect of a receiver having flexible walls. In the latter case the effect was enhanced, and the pulsation error became easier to get rid of. In 1915 he had experimented with the measurement of air consumption in a Vauxhall engine. He used an instrument having a balanced gate controlled by a spring. There was a slight amount of throttling. With a receiver having flexible walls it was possible to get a steady and accurate reading of air consumption on the gate. The gate was preferable to an orifice for that kind of work because in using a differential pressure method it was necessary (1) to damp down the pulsations of flow backwards and forwards and (2) to damp down the pulsations of pressure. He had started an investigation, on Dr. Moss's lines, to get the brake horse-power ratio to air consumption, and although the experiments were never finished, the results obtained were similar. Mr. Hodgson then spoke of the arrangement of an orifice inserted in a pipe, which had advantages over the orifice box, stating that he had calibrated such orifices down to $\frac{1}{100}$ in. of water up to 2,000 in. water gauge. By using mixtures of glycerine and water the range of calibration could be greatly increased. In concluding his remarks, Mr. Hodgson described the compressed-air plant at Ragged Chutes, Ontario, at which facilities had been extended to him for his orifice calibration investigations.

Mr. H. T. Tizard, who followed, said he was interested in Dr. Moss's paper because of the importance of getting some accurate measurement of the I.H.P. of an engine in flight. The ordinary indicator could not be used in flight, but an indicator had been developed at the R.A.E. which it was possible to use. At the same time it was liable to errors which had not yet been overcome. He thought that Dr. Moss's method of measuring air consumption would prove of great use for aircraft purposes. He thought, however, that Mr. Hodgson could not have conducted any experiments in the air, judging by his reference to Dr. Moss's method as the simplest and most perfect for air measurements in flight. Flight experiments were hampered by limitations of room, of comfort and human endurance. The instrument shown by Dr. Moss was very complicated for accurate operation by an observer in an aeroplane. On that ground he considered the Venturi method worth fuller investigation under flight conditions, in combination with the author's instrument, on two or three aeroplanes. During the war—to obtain relative figures of air consumption in flight—he had carried out a few experiments on the depression in the choke tube of the carburettor. He never anticipated accurate measurements, but the results were very consistent. It was an obvious thing to say that pulsations would upset the measurements, but he thought that, with a multi-cylinder engine, the pulsations were not a very great disadvantage in the particular case. In the development of new engines for aircraft purposes it was very desirable to have a simple method for getting at air consumption. He hardly regarded the author's method as simple enough, and would like to see some comparative measurements as between the more accurate method of Dr. Moss and the Venturi method properly applied. The diagrams shown illustrated the reasonable expectation that with an engine tested at its best conditions, with full throttle, the indicated horse-power would be proportional to the air consumption, but there seemed to be some discrepancy in the mechanical losses recorded by the author.

Mr. A. E. L. Chorlton said that he would have expected greater differences to be shown under the varying conditions, and he would ask if the meter had been used over a wide range of changes, either in the adjustments of the carburettor or of the ignition itself. The initial calibration of the instrument and its relation to the duty it was to perform seemed to be rather exact and narrow. Could the instrument be applied to engines indiscriminately, without knowing the variable factors? From the standpoint of general use the instrument seemed rather limited in its application; apparently a good deal of testing would have to be done if it were applied indiscriminately. Had the author's method of measurement been tried with the exhaust? Years ago tests had been made by exhaust calorimeters. The exhaust would govern the power of the engine, taking account of the fuel and air. He was aware that his remarks were concerned with the power side, the practical application, at which most members would look with regard to compensators or damping devices. Something really definite in the way of damping would be of much value to many engineers. Years ago he had made experiments on damping the exhaust, partly to damp and partly to govern the period of the vibrations in, say, a two-cycle engine, to get them properly coincident with the exhaust itself. Since those tests were made a great deal had been done—and the more that could be done the better—to show exactly how adequate control could be effected (1) to damp the vibrations and (2) to control them.

Mr. William Reavell next asked what coefficient was used and what formula with the sharp-edged orifices. The paper would be more valuable if it were possible to follow the calculations exactly, to see how the electrical instrument was calibrated. He was surprised, in view of what had been done in recent years, that a sharp-edged orifice should have been used. Had the author used a propelling nozzle with a very slight pressure difference he would as was well known, have obtained a coefficient of practically unity, 0·99, as he (Mr. Reavell) had shown in his paper read before the Institution eighteen months ago, on the question of the measurement of air and gases.* The whole calculation, under such conditions, was rendered much simpler for the engineer, since a simple hydraulic formula could be used. He appreciated that a properly calibrated electrical system of measuring, like that under discussion, should be very compact and simple for aeroplane work. However, a really dependable Venturi system would be simpler still. For the general industry of air compression he questioned the applicability of Dr. Moss's method. Would inspectors accept it? It would be difficult to prove to the inspector that the figures were all right. If an inspector were shown a large air receiver he had a known volume, and could take the time with a stop-watch; he would accept the results, although probably wrong, within limits. Then there were nozzle tests, beginning with a sharp-edged orifice and the later forms of propelling nozzles; by applying the hydraulic formulas he had described, avoiding exponential equations, the inspector would have something with which he could deal. He did not see how an inspector could satisfy himself about the electrical tests. It had been pointed out that experiments with the latter method should not be made in a fog or rain unless corrections were applied. An inspector's visit, however, could not be deferred on account of fog or rain; experiments had to be made in spite of atmospheric conditions, and the corrections for moisture applied. Mr. Chorlton had raised the question of measurement of the exhaust. The exhaust was seldom pure and might contain unburnt carbon, oil, and so forth. Delivery from an air compressor or turbo compressor was usually measured on the delivery side, and the air was, of course, not always pure. In a reciprocating compressor there might be burnt oil—certainly oil vapour. How would that affect the electrical resistance of the grid used? Scientifically the method appeared to be sound and correctly based on known laws.

Mr. L. A. Legros said that the road automobile engine was designed for running at constant torque, as nearly as might be; that was to say, when the car was climbing a hill or on difficult road, it should produce as nearly as possible a steady torque, so as to avoid gear changing over a large range of speed. He had pointed this out to the Institution of Automobile Engineers many years ago, and the practice had nearly become standard with the makers of the leading types of car. The question had become complicated by the influence on engine design of the Taxation Acts, as a result of which developments had led away from the slow speeds to engines of much higher speed. The aircraft engine ran normally at full load, but as the machine rose the pressure fell, so that it worked in air of a different medium, though as nearly as possible at full load all the time. He felt that while the information submitted was largely of use to the designer of aircraft engines, it would be an advantage to automobile designers if further experiments were carried out with regard to car engines.

There was at present no idea of the amount of air used in relation to indicated horse-power in the case of small automobile engines, and he did not think anyone had taken pains to consider the point for many years past. The engine could be motored round, and, if run on the electric brake, readings could be obtained from the electric generator. The brake horse-power was the only item of interest, and that was more interesting as torque than as actual brake horse-power. If it were possible to have the relationship between air and brake power plotted to a scale of revolutions, the figures would assist the manufacturers of small engines, particularly the carburettor people.

Captain H. P. Riall Sankey was the next speaker. As he understood the paper the author obtained a constant factor both for indicated horse-power and brake horse-power. He could understand that if the loads at which the tests were made were not very different. Supposing, however, the load were varied. Then, taking 100 i.h.p., with the factor of 2, and assuming that the loss was 25 h.p., giving the brake efficiency, at full load, of 75 per cent., then the factor for brake horse-power would be 2·7. As the load was reduced to 75 per cent., and assuming that the loss would be the same, *i.e.*, 25 h.p., that would give 50 b.h.p., the factor then becoming 4. Reducing the i.h.p. to 50, and deducting the 25 h.p., would give 25 b.h.p. The factor would be 8. At 25 i.h.p. there would be no brake horse-power and the factor would be infinite. He was afraid that the author's results were liable to be misread in this connection.

The President remarked that he had also been struck by the point Captain Sankey had referred to. The value of the air did not fall off as the load went down; on the contrary, it was constant, and, as he read the authors' curve, it disclosed a rather curious state of affairs. He was much interested in the method described of measuring air. In Detroit the Thomas meter had been used for measuring air for big boilers as far back as 1911 and in 1914. In the case of the second application, those in charge were not altogether satisfied as to the correctness of the formula used, and calculations were made in the Research Department, cubic feet of air per minute being plotted from the Thomas air meter against figures from nozzle tests. The results gave a straight line showing the Thomas method to be correct. Referring to the pipe of 3½-in. diameter used by the author, the tube used in the Detroit work had an area of 6 ft. by 5 ft., or 30 sq. ft. In Detroit they took air from the basement in the boiler room, and there was therefore no water in the air to affect the apparatus.

Dr. Moss, in reply to the discussion, said he did not think the presence of water vapour would make much difference, but if water were present in the liquid state of drops, as in fog or a cloud, the difference would be appreciable. He admitted that his apparatus was complicated in comparison with the Venturi tube, but once the instrument was made up any ordinary observer could learn to use it. His chief objection to the use of the Venturi tube on an engine was this, that the air vibrations were not constant or consistent. When applying a Venturi meter to an engine and calibrating it under the anticipated conditions, it did not follow that the next time the engine was used it would show the same vibrations and the same results. With regard to his figures, there was no slip in getting the result that the indicated horse-power was proportional to the air. The loss shown between the dotted line and the full line on the diagram had not been checked by theoretical calculations, because he did not think that there were any such calculations that could be applied to the apparatus. Air could not be used to measure horse-power if the mixtures were weak. He

* See ENGINEERING, vol. cxiv, page 690.

thought he had explained that in the introduction to the paper. He had tried to get the maximum power with the mixture always slightly strong. In reply to Mr. Reavell's remarks, it really did not matter whether a nozzle or an air box was used for calibration purposes. The box would in any case be used to get steady flow, and the simplest course was to put the sharp-edged orifice on the box; as the experiments formed a comparison test, the point was not important, the aim being to see that the instrument maintained its purpose with a steady flow and with a variable flow.

As to the use of the instrument with compressors, the instrument was developed for the measuring of air flow on the road and in flight; it was not recommended for other cases, such as on the ground, where simpler methods were available. Nor was it recommended when it was known that the air was steady; if the air were perfectly steady, an orifice across the pipe or a nozzle, or any other method, could be used. The instrument was designed to meet the case of the internal-combustion engine, in which it was known that the air was not steady, and also cases in which pressure and temperature might vary a good deal. With regard to Captain Sankey's question, he would say that he had found that the indicated horse-power, within the accuracy with which it could be measured in order to repeat it, was proportional to the air, but the brake horse-power was not proportional to the air. Over a much larger range than he had worked on, as in the case of the motor-car engine, the brake horse-power would certainly not be proportional to the air. He had taken the indicated horse-power as proportional to the air, and calculated the losses to get the brake horse-power.

The President then announced that the next general meeting would take place on Friday, May 9, at 6 p.m., when Mr. Richard Allen would read a paper on "Irrigation Pumping Machinery."

Eddystone Lighthouse—Smeaton Model.

Lieut-Colonel E. Kitson Clarke then described an original model made by Smeaton, temporarily in his possession. The model had belonged to the last member of the Smeaton family, who had lived in the district where Smeaton was born. It was of the base of the Eddystone Lighthouse, in the building of which the main difficulty was to key the immense weight of the structure on the sloping side of a great rock subject to very heavy wave pressure. The model exhibited showed how Smeaton had designed the cutting of the stones so that they should dovetail into the actual rock and also into each other in different layers. Each layer was carefully drawn out, and all the stones were dovetailed one with another. It proved a great success. The last man who took an interest in the model had died the previous week, and it had come into Colonel Kitson-Clarke's hands prior to being placed in the Leeds Philosophical Museum. Colonel Kitson-Clarke also produced a book in which Smeaton described how he designed the stones. It was interesting to note that in a building made in 1716 the stones were of exactly the same kind as could be seen in the model made by Smeaton himself. Smeaton, in his dedication to His Majesty of the book, a copy of which was fortunately in the Institution's Library, had used the following words: "I have it not in my power to present your Majesty with a fine piece of writing or a drawing, neither literature nor the fine arts having been much the object of my study, but I humbly submit to your Majesty a plain account of the construction of a plain and simple building, that has, nevertheless, been acknowledged to be in itself curious, difficult and useful, and as such, I trust, worthy of observation."

Association Technique Maritime.—We have received from the Association Technique Maritime the volume of its Proceedings at the 27th session, held on July 6 and 7 last. It contains the following papers which were read on those two dates: "Reflections on the Jutland Battle"; "The Salvage of Ships"; "Vertical Landing of Aeroplanes"; "The Future of the Hydro-Glider"; "An Account of the London International Conference of 1914 for Safeguarding Human Life at Sea"; "Fatigue of Materials and Safety of Constructions"; "A Synthetical Study of Naval Material"; "On the Use of Gyroscopic Reference Marks on Board Ship"; "On the Stability of Ships."

LITERATURE.

Sugar Machinery. A Descriptive Treatise devoted to the Machinery and Processes used in the Manufacture of Cane and Beet Sugars. By A. J. Wallis-Taylor, A.M.Inst.C.E. Illustrated. London: W. Rider and Son, Ltd. 1924. [Price 12s. 6d. net.]

The sugar industry is one of great importance, not only by reason of the capital involved and the numbers to which it gives employment, directly and indirectly, but also for the important part it has played in the progressive development of the dependencies and protectorates of the Empire. It has of necessity called forth an abundant technical literature, provided by experts of acknowledged eminence, all urging the desirability of extending the manufacture, and of making the empire self-supporting in the important item of sugar. The contribution of the author takes the form of an inquiry into the principles and construction of the apparatus supplied for facilitating and improving the manufacture, with necessarily some description of the processes, by way of illustrating the purpose in introducing modifications in the mechanism used in different centres.

To those who have not studied the great strides made in mass production of sugar, and regard Hawaii, Fiji, and other less known islands as mere geographical expressions, it will occasion some surprise to learn the scale on which operations are conducted and the opportunities afforded for well-considered enterprise, possibly not unmixed with disappointment, when it is appreciated that English activity struggles a long way behind the vigour exhibited elsewhere. Comparing the output of the two centres Hawaii and Fiji, it is to be noticed that in the former, where the forceful energy of the United States predominates, the export was 640,000 tons, while on the Fiji Islands, capable of using a considerably larger area for cultivation of the cane, the production for the same year amounted to only 120,000 tons. Some of the factories round Honolulu are designed for and capable of handling as much as 3,600 tons of cane per 24 hours, yielding no less than 550 tons daily of commercial sugar, about 96 per cent. pure. Against these figures, and as presenting another picture of the sugar industry, it may be mentioned that United States statistics show that the quantity of sap produced from the maple (*Acer saccharinum*) in 1913 was 4,106,418 gallons, yielding 14,060,206 lb. of sugar. It is not the quantity that is so striking, though that is large, but the patient industry that prepares and bores the bark of the tree, collecting the scanty discharge of sap, drop by drop, at the rate of about 18 drops in five minutes, when the yield is most abundant.

These and similar figures affect us in two ways: first, they demonstrate the inadequacy of our feeble efforts in encouraging a competing, or even contributing, beet industry, handicapped, as it necessarily must be, by higher land rent charges, expensive manures, and highly priced labour; secondly, and more immediately connected with our present purpose, they suggest the provision of apparatus and machinery on an equally vast scale, benefiting the engineering firms who have specialised in this class of work. It is only necessary to summon up in thought the equipment of a modern sugar factory, to watch the tons of canes that are being brought up in endless succession, to imagine the crushing mills, supplied with individual furnaces, boilers and fuel feeders (these latter essential where, as in many factories megass, the waste from the crushing mill, is used as fuel); to observe the work of the clarification and filtration plants, the evaporators and vacuum pans, the centrifugal machines for drying grained sugars, with much accessory apparatus—to appreciate the possibilities before the engineer and the heavy task facing the author. This slight catalogue of the matters treated leaves out of sight provision of electric power for working conveyors and pumps, the tanks for the treatment of molasses, and the work of distillation of rum.

Needless to say that this varied equipment as used to-day is not the work of one age, or of a few inventors. The author invites us to study the evolution of the machinery, to contrast the difference of construction recommended by various firms, and to estimate the value of each new adjunct that experience in the factory has shown to be desirable, or ingenuity has suggested to those who have specialised in this branch of engineering. In the wide field of inquiry in which the author has elected to work, it would not be difficult to show that there are omissions. But his description is comprehensive, the illustrations clear and informing, and quite a sufficient number of examples have been selected. Necessarily much similar apparatus is found in other branches of industry, but Mr. Wallis-Tayler traces very accurately the variations essential in the conduct of sugar manufacture. The conveyance in bulk of heavy materials of small value, requiring tram lines and locomotives or the construction of aerial wire rope-ways for efficient transport, is not peculiar to the sugar industry. Crushing apparatus finds application in many industries, though the principle of multiple crushing may have its fullest development in the handling of cane. Similarly with evaporators and vacuum pans, though their general principles are well known, one may learn here the special devices that have been adapted to fit them to the special demands of sugar manufacture.

The author seems less at home with the processes employed in beet-sugar manufacture. He does not exhibit quite the same familiarity with details, and apparently the information is drawn more from the experience of others than gained in his own practice. It is stated that in the extraction of waste sugar from molasses, barium hydrates are used in the place of lime or strontium. We should doubt this, for though recent improvements have, been made in the preparation of barium carbonates with the view of increasing the purity, it is doubtful if any Government would permit the use of barium on account of its toxic properties. It seems not unlikely that the description of the osmose process has been adopted from the earlier edition of the work, on which this treatise is founded, for the method, though long used in France and Belgium, is practically abandoned.

The Calculus of Observations: A Treatise on Numerical Mathematics. By E. T. Whittaker, Sc.D., F.R.S., Professor of Mathematics, and G. Robinson, M.A., B.Sc., Lecturer in Mathematics, in the University of Edinburgh. Blackie and Son, Limited. 1924. [Price 18s. net.]

Those of us, who think that the aim of mathematical teaching should be to give a definite and easily comprehensible answer to the problems of which it treats will note with satisfaction that the Professor of Mathematics in Edinburgh has long directed his attention to training his class in the laborious work of numerical calculation, and has instituted a Mathematical Laboratory, in which the results of general mathematical analysis are applied to particular problems. He evidently attaches great educational value to the process of mastering the arithmetical details that assist enquiries in physics, biometrics, actuarial science, astronomy, &c. There is another class, however, which regards with reverence the secrets locked up in mathematical formulæ, and resent any attempt to make these treasures available for advancing other sciences. They conceive that their duties are exhausted by indicating the proofs of valuable formulæ and the methods by which they are utilised. They have neither the intention nor the ambition to create technical experts. Professor Whittaker tells of a 17th century mathematician who found the process of deriving the roots of algebraical equations so onerous, that he declared it was work unfit for a Christian. In these days, close attention to numerical details has been thought unfit for a gentleman. A rough graph, or the use of a sliding scale that might furnish an inadequate approximation to some ingenious theory was the most that could be tolerated by one who interested himself in the higher analysis.

We are grateful to the author for the assistance he gives to those who would get the utmost from the tools mathematics provides. He figures as the apostle of accuracy, and sets his face sternly against those devices that satisfy the consciences of weaker brethren. The material equipment he allows his class is simple and severe: a copy of Barlow's

Tables, of Crelle's Rechentafeln, and a seven-place table of logarithms are the simple accessories that enable him to turn out admirable results from carefully marshalled data. Even a table of five-figure logs is excluded, and apparently at no stage of the course is a slide rule permitted. The use of graphs is only sparingly allowed. It is informing to note that an experience of more than ten years in conducting a mathematical laboratory, designed to train pupils to solve numerical problems of every degree and variety, finds graphical methods unsatisfactory and laborious. It may come as a surprise to some to learn that graphical work performed carefully with instruments on a drawing board, is generally less rapid and less accurate than the rigorous arithmetical solution of the same problem.

To the proficient much is delightful that bores and troubles the inexpert. The passion for accuracy may become too absorbing and time wasting, the charm of pursuing the repetition of some ingenious device may prove too fascinating, if no useful purpose is served by the exercise. We have been taught that to spend too much time in studies is sloth, and great facility in the handling of figures may become a tiresome obsession. The well-known equation by which Wallis illustrated Newton's method of solving a cubic equation

$$x^3 - 2x - 5 = 0$$

furnishes an example of this danger, since it led an ingenious gentleman to determine the root to 51 places of decimals, a labour that tempted another enthusiast, dissatisfied with this degree of approximation, to continue the endless string of decimals to 101 places. It is possible to abuse a desirable accomplishment.

Professor Whittaker begins with the subject of interpolation, that art by which we are able to compute from certain known numerical values of a function, the value for some intermediate value of the variable quantity or argument, without knowledge of the analytical expression on which the function depends. There may be cases in which the theory of interpolation fails, but dealing only with practical matters, the author does not discuss these cases, he assumes that the function is continuous between the limits within which it comes into consideration. On the other hand, however, he adapts the formulæ for unequal intervals of the argument, a process which though less frequently used is a very desirable addition. The historical notes scattered through the section are very interesting, and may correct many false impressions, which those who have used the formulæ of Gregory, of Newton or of Stirling have entertained.

The process for effecting numerical integration might well have followed the discussion of interpolation in its many forms, and the introductory chapter on determinants and linear equations brought into closer connection with the method of least squares, but the author has preferred at this stage to introduce a long chapter on the solution of algebraic and transcendental equations. So many great mathematicians have busied themselves with the mechanism for deriving the roots of these, that the chapter, wherever inserted, cannot but be of profound interest, as exhibiting the growth of insight and ingenuity, as well as the attitude of modern algebraists towards the methods of the past. The principle of iteration as proposed by Newton, modified by Raphson, and improved by Dandelin and others is well illustrated. The student of the History of Mathematics will be grateful for the reference to Bernoulli, permitting as it does a contrast between the methods of his date and those in vogue since. The writer of this note has had in actual practice no experience of Græffe's method, but a device that has the advantage of finding all the roots at once, without requiring any preliminary determination of their approximate position, with the peculiarity that the roots are widely separated numerically in the equation actually solved, is promising and ingenious. In this chapter, the author looks a little more leniently on the method of graphical solution, and acknowledges its assistance in certain cases. He unbends, too, towards the modern system of nomography. The practical view taken, quite warrantably, is that unless graphical methods save time they are useless. Waste of time they may cause is due in a great measure to constructing a fresh diagram for every problem that has to be solved. In nomography, on the other hand, it is possible to apply the same diagram to the solution of many problems of the same type, however varied the numerical coefficients may be. As an original contribution to the subject, Professor Whittaker submits a simple diagram, consisting of two rectangular axes at right angles, and a circle touching one axis, that, by the system adopted for dividing the axes and periphery of the circle, can be made capable of solving all quadratic equations of the form

$$x^2 + ax + b = 0$$

With a touch of Scottish humour, Professor Whittaker says that the proof may be left to the reader. We shall not attempt to disturb this programme.

A large section is necessarily devoted to the consideration of the validity of the basis on which the method of least squares is established, and the derivation of numerical results from equations of condition and from the combination of repeated observations of the same or similar quantities. A great change has come over the treatment of this powerful aid to numerical analysis, since Gauss arranged the engine so universally used to determine the most probable values of the unknowns of a system of linear equations. The problem before him was to determine a planetary orbit from an indefinite number of observations, and for many years astronomers practically monopolised the contrivance. The principles that the most probable values of the unknown quantities are those which make the sum of the squares of the residuals a minimum, the probability curve, the criterion for the rejection of discordant observations, and the determination of "weights" were some of the avenues by which they advanced to the practical application of general principles, but now other sciences adopt similar processes of combination and new roads and fresh illustrations demand consideration.

The practical problem still remains the same, to derive the true measure of an observed quantity from a number of more or less inexact observations, and to estimate the error to which the deduced value is liable. The theory of frequency distribution, as originally indicated by Laplace seems now to offer a more logical approach to the investigation than that indicated by Gauss and Legendre. The authors discussion of our old friends in a modern dress requires a good deal of reading, and it is a very difficult task to hold all the steps of the proof in their proper relations, and draw a conclusion that gives to each its true weight. Even the postulate of the arithmetic mean is made the subject of attack, but as we think a little unfairly. The original method deals with accidental errors and has nothing to say to systematic. The illustration founded on the effects of the Weber-Fechner psycho-physical law, introduces irregularities of observation not contemplated under the Law of Error.

Apparently only one method has been devised for the laborious work of forming the normal equations, but there are several ways for effecting the numerical solution. We doubt if these alternatives have penetrated into observatories. The method of Gauss, as described by Encke, is the only one in general use in England, and those are fortunate who have been led to study more modern methods. Dr. Whittaker's experience leads him to prefer the determinental method as superior to that of Gauss or that known as "equal coefficients," but the superiority of the method of determinants rests on the fact that a set of normal equations is from the plan of construction always axisymmetric, for linear equations not possessing this peculiarity the device of Gauss holds its own.

Another form of analysis that has attracted much attention in late years is that connected with the series of Fourier, invaluable for the solution of a particular class of problems in physics, astronomy and meteorology. The method as usually and conveniently applied is worked out very thoroughly, and a complete example is given showing the application of the method to the determination of the light curve of a variable star. The curve is also drawn and compared with the observations, exhibiting a success that may tempt some to apply the method without understanding the theory on which it rests. This principle of the periodogram which Professor Schuster has utilised so successfully, must, unfortunately, be passed over with this reference, and one would have dwelt with pleasure on some of the curiosities and mathematical puzzles, but to make these intelligible too much space would be required. The chapters on correlation and on the smoothing of data are very attractive, but those who read the book carefully will find that this obvious remark might equally well be made of every page.

BOOKS RECEIVED.

Modern Wood-Working Machinery. By STAFFORD RANSOME, M.Inst.C.E. London: William Rider and Son, Limited. [Price 12*s.* 6*d.* net.]

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United States Coast and Geodetic Survey. Annual Report of the Director to the Secretary of Commerce for the Fiscal Year ended June 30, 1923. Washington: Government Printing Office.

United States Bureau of Foreign and Domestic Commerce. Statistical Abstract of the United States, 1922. Washington: Government Printing Office. [Price 75 cents.]

Aeronautical Research Committee. Reports and Memoranda No. 887. *Experiments with a Close Tandem Airscrew Pair.* By E. J. H. LYNHAM. London: His Majesty's Stationery Office. [Price 3*d.* net.]

Report of the Air Survey Committee. No. 1, 1923. London: His Majesty's Stationery Office. [Price 4*s.* 6*d.* net.]

Oil Burning Installations. By C. C. POUNDER, A.M.I. Mech.E. Manchester and London: Emmott and Co., Limited. [Price 12*s.* 6*d.* net.]

Bulletin de l'Association Technique Maritime. Vol. 27, *Session de* 1923. Paris: Association Technique Maritime.

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PERSONAL.—Sir Alex. Binnie Son and Deacon state that they have taken into partnership Mr. Harold J. F. Gourley, M.Eng., M.Inst.C.E., F.G.S., who has been intimately associated with the firm for many years.—Ormerods' Tool Co. Limited, Hebden Bridge, have removed their London office from 10, Eastcheap to 302, Abbey House, Victoria Street, S.W.1. Telephone: Victoria 1239. Telegrams: "Abelard" Sowest, London.

OXYGEN-BREATHING APPARATUS FOR AVIATORS.

CONSTRUCTED BY MESSRS. SIEBE, GORMAN AND CO., LIMITED, ENGINEERS, LONDON.

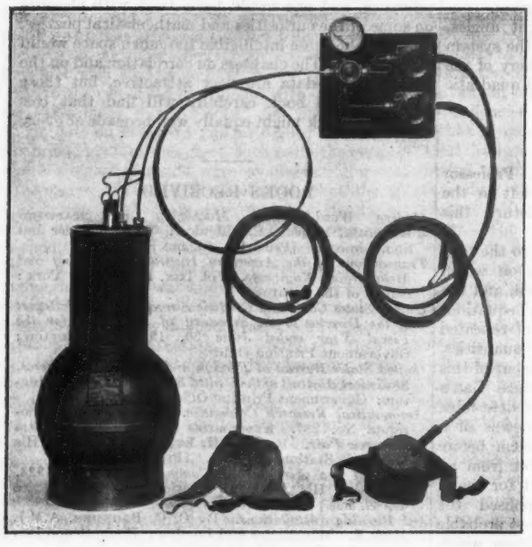


FIG. 1. OXYGEN-BREATHING APPARATUS USING LIQUID OXYGEN.

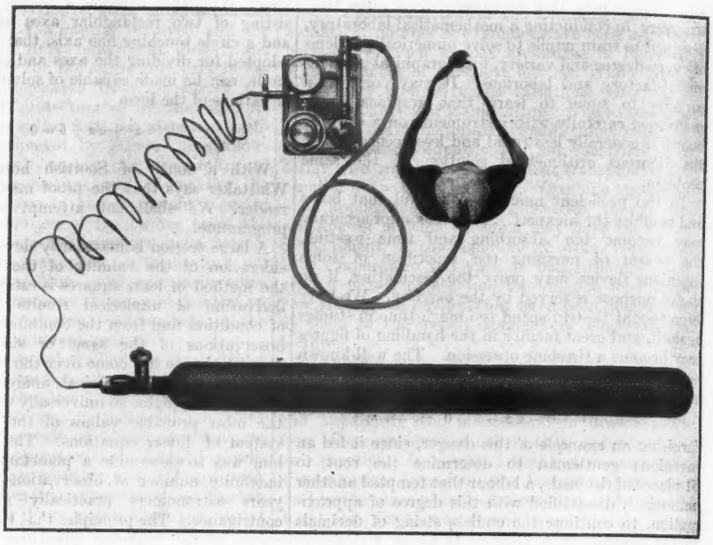


FIG. 2. OXYGEN-BREATHING APPARATUS WITH STEEL GAS CONTAINER.

OXYGEN-BREATHING APPARATUS FOR AVIATORS.

AMONG the aeronautical exhibits to be shown at the British Empire Exhibition is apparatus, illustrated on this page, for supplying oxygen to airmen flying at great altitudes. This apparatus is manufactured by Messrs. Siebe, Gorman and Co., Limited, 187, Westminster Bridge Road, London. The firm makes two types of apparatus, both of which are illustrated.

Fig. 1 shows the type in which the oxygen is carried in the liquid form in a vacuum-walled metal vessel embodying the principles of the Dewar flask. The vessel, and the combined oxygen vaporiser, is shown on the left of Fig. 1, and, as will be seen, it is connected by means of two small-bore copper tubes to a pressure gauge and regulating valve which are mounted on the dashboard of the aeroplane. From the regulating valve, the oxygen gas passes through two flow meters, which indicate the quantity of oxygen passing, and thence is conveyed through flexible tubes connected to masks which fit over the face of the pilot and observer when the apparatus is in use. The vacuum vessel holds 4 litres of liquid oxygen, and assuming the consumption of each man to be about 2 litres of oxygen gas per minute, the supply would sufficient for about 10 hours. The actual consumption of oxygen, of course, depends upon the altitude, more being required at great heights than at lower levels. The weight of the oxygen vessel is 12½ lb. and that of the control apparatus 3 lb.

In the apparatus illustrated in Figs. 2 and 3 the oxygen gas is contained in a light steel cylinder at a pressure of 120 atmospheres. At this pressure the cylinder, which is 3 ft. 2 in. long and 3 in. in diameter, is capable of holding 15 cub. ft. of free gas; the weight of the cylinder is 18 lb. As shown in Fig. 2, the cylinder is connected by a small copper tube to a pressure gauge and reducing valve from which the gas passes through a control valve and flow meter to a flexible tube connected to a mask worn over the mouth and nose of the pilot. The controlling components are all mounted on a metal frame shown to a larger scale in Fig. 3, in which the items mentioned above are all easily recognisable; the weight of this part of the equipment is 2½ lb. With a continuous flow of 2 litres per minute, the cylinder capacity would be sufficient to maintain a supply for 3½ hours.

THE PLATING OF ALUMINIUM.

THE protection of aluminium by electro-plating formed the subject of a lecture delivered by Professor C. H. Desch at the annual general meeting of the Sheffield section of the Institute of Metals, held on April 11.

Professor Desch stated that when aluminium was exposed to the atmosphere it became coated with a thin film of oxide which arrested further corrosion. The presence of chlorides in the atmosphere, however, attacked this protective oxide coating and, whereas the aluminium parts of land aeroplanes remained serviceable for considerable periods, seaplane aluminium parts corroded rapidly. The severe corrosion of the exposed aluminium parts of German Zeppelin airships, examined at the National Physical Laboratory, had, in a large measure, been brought about by exposure to sea air. It was therefore desirable to find some way of protecting the metal, and one method was to make the oxide surface skin more resistant by electro-chemical means. This could be accomplished by treating the aluminium in an alkaline silicate bath, the coating of oxide deposited contained some silicate which increased its resistance to corrosion. Another process involved the use of a di-chromate electrolyte. The yellow skin obtained on the surface of the metal contained chromium and withstood corrosion very well.

Turning to electro-plating, Professor Desch described a series of experiments, carried out with the help of Mrs. E. Vellan, having as their object the finding of an efficient protective covering for aluminium. The porous character of commercial aluminium presented a real difficulty; particles of soda or potash from the preliminary cleaning bath remained occluded, even after prolonged washing, and, sooner or later, produced blisters upon the plated surfaces. A second dipping bath containing acid ferrous chloride was tried, followed by the deposition of a thin film of iron upon the surface of the aluminium, but the blisters persisted to such an extent that the potash treatment and the ferrous chloride dip were abandoned altogether. Sand-blasting was substituted for chemical cleaning and proved entirely satisfactory. Copper, nickel and iron could be deposited with ease upon aluminium and, in cases where the building up of aluminium parts was desired, thick coatings of iron could be obtained electrolytically, using a concentrated solution of ferrous ammonium sulphate made faintly acid with sulphuric acid. The deposits so obtained were wonderfully strong and adherent and were capable of being subsequently ground to the required size. Thick deposits of nickel had also proved satisfactory, the bath in this case consisting of nickel chloride or a mixture of the chloride and sulphate of nickel, together with boric acid. The best and most promising results, however, were obtained by using cadmium. The surface of the aluminium was first sand-blasted, then coated with a film of iron, sand-blasted again and finally placed in the cadmium bath. After a great deal of research it was found that the best solution to use was one containing cadmium ammonium sulphate with peptone as the addition agent. The bath was maintained at room temperatures, cast anodes were used, and the current density kept at from 5 amperes to 7 amperes per square foot. The deposit obtained withstood burnishing, was white, firmly adherent and finely crystalline. The subsequent heating of cadmium-coated aluminium was tried, but met with indifferent results. In the case of cadmium-coated steel, said Dr. Desch, the deposit could be further improved by subsequent heating, which caused the two metals to alloy at the surface. Specimens of cadmium-plated aluminium were subjected to the very severe "salt-spray" and "water-line" tests with highly satisfactory results. The only objection that could be raised against cadium plating was the increased weight it imparted.

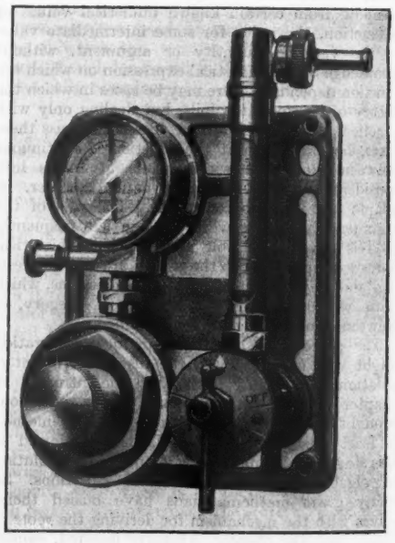


FIG. 3. CONTROL UNIT FOR OXYGEN-BREATHING APPARATUS.

AIR CONSUMPTION AND POWER OF PETROL ENGINES.

*The Relationship of Air Consumption to Brake Horse-Power in Internal-Combustion Engines; Road and Flight Tests.**

By H. Moss, D.Sc., A.R.C.S., D.I.C.

Introduction.—The air consumption of an internal-combustion engine is of interest, not only of itself as one of the determining factors of its efficiency, but as a possible means of obtaining the brake horse-power under running conditions, *e.g.*, in road tests of a motor-car engine or flight tests of an aero-engine. If the air-petrol ratio is exactly that required for perfect combustion (about 14), the available heat per gram of air is a maximum. With excess of air no further heat is obtained, and the heat per gram of air diminishes. With excess of petrol the heat per gram of air diminishes from two causes. A portion of the air which with perfect combustion would convert one gram of carbon to carbon dioxide, now converts two grams to carbon monoxide, but the heat thus liberated is approximately only one-half. In addition, some petrol passes through unburnt, but abstracts heat for its vaporization. The indicated horse-power depends on the available heat, the type of engine, and the manner of burning, which last is affected by the spark setting and the throttling. Finally, the brake horse-power is given by the indicated horse-power and the mechanical efficiency, which latter depends on the speed and load. The relationship between air consumption and brake horse-power is thus very complicated, but under conditions of maximum power tests with air-petrol ratios lying between 11 and 14, the indicated horse-power is always found to be very nearly proportional to the air consumption, while, owing to the high mechanical efficiency of modern petrol-engines, the brake horse-power departs very little from proportionality. Some experiments on the relationship are given in this paper, and for the type of engine used the departure was in no case more than 4 per cent.

Method.—The method adopted in the present experiments is based on the method of continuous flow electrical calorimetry as developed by Professor H. L. Callendar, in which heat is added electrically at a measured rate to a stream of liquid or gas, and the consequent rise in temperature of the stream observed. From the rate of heat supply and the rise in temperature, the specific heat of the liquid or gas can be calculated if the rate of flow is known and vice versa, the rate of flow can be calculated if the specific heat is known. In 1918, Professor Callendar devised means of temperature compensation which enabled the method to be used with accuracy at the low temperatures prevailing at high altitudes and, assisted by Mr. W. J. Stern, constructed and tested a working model. Early in 1920, the present author was asked to take up the problem, and has been responsible for its subsequent development.

Theory of the Method.—If a steady current of air equal to W grams per second is heated by an electric current flowing through a resistance coil of R ohms, with a difference of potential of V volts on its terminals,

$$JSW\,dT = \frac{V^2}{R},$$

where J is the mechanical equivalent of heat in joules per calorie, S is the specific heat of air, and dT is the rise in temperature in degrees Centigrade.

Thus

$$W = \frac{V^2}{RSJ\,dT}.$$

As S does not vary appreciably with temperature or pressure, JS is constant and is approximately equal to unity, so that $W = \frac{V^2}{R\,dT}$. If the resistance coil R is made of material which also remains constant at all temperatures experienced, we have $W \propto \frac{V^2}{dT}$. The voltage can be adjusted by a rheostat to give a constant rise in temperature, so that finally $W \propto V^2$. A measurement of V thus suffices to determine W.

Fig. 1. ELECTRICAL CONNECTIONS OF AIR FLOWMETER.

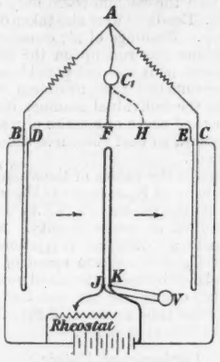


Fig. 2. ELECTRICAL CONNECTIONS OF VOLT-THERMOMETER.

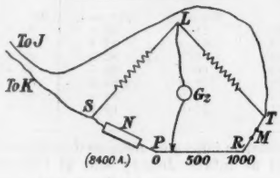


Fig. 3. ELECTRIC AIR THERMOMETER FOR ENGINES UP TO 40 H.P. (APPROXIMATE MAXIMUM FLOW, 40 GRAMS PER SECOND).

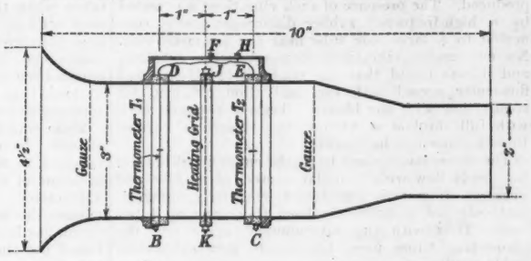


Fig. 4. NICKEL WIRE RESISTANCE THERMOMETER.

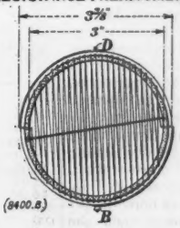


Fig. 5. "CLIMAX" HEATING GRID.

By employing a resistance coil in the form of a mat with resistance equally distributed over the cross section of the flow tube, the rise in temperature of the air current can be made approximately uniform. But since this condition cannot be exactly satisfied, it is most essential to employ for measuring the temperature rise, a pair of differential resistance thermometers of bare wire, the grids of which are uniformly wound and placed at equal distances on either side of the heating mat, so that any radiation errors are also balanced and eliminated.

The difference of temperature between the two thermometers can be accurately measured by the Wheatstone bridge method. If the bridge is initially set 1·5 deg. C. out of balance, the heating current can be adjusted by a rheostat until the galvanometer needle returns to zero. The voltage required can then be measured. The adoption of a constant temperature rise simplifies both the apparatus and the calculations. In bench or road tests any accurate voltmeter may be used for the measurement. In flight tests, the voltage is measured by Professor Callendar's volt-thermometer method, which has a zero method reading, and which can be compensated for temperature effect with a high order of accuracy. In this method the voltage is applied to the arms of a Wheatstone bridge, in one branch of which is a very fine platinum wire. The change in resistance of this wire due to heating is a measure of the voltage applied.

Electrical Circuits.—The electrical connections are shown diagrammatically in Fig. 1. Across the central section of the instrument is the heating grid JK, and on each side are the two thermometers BD and EC. The resistances AB and AC form the equal arms of a Wheatstone bridge for measuring the temperature rise. The two other arms consist of the two thermometers, which were connected together by a length of wire DE, Fig. 1, F being the balance point when no current is passing through the heating grid. When a current of air is flowing in the direction shown, and the electric current is passing through the heating grid, EC is hotter than BD and its resistance is higher. The new balance point is represented by H, the resistance of FH being half the increase of resistance of EC. The point F was found by trial with medium air flow when no current was passing through the heating grid. It was found that the current passing through the thermometers was sufficient to heat the air slightly at small flows, so that the position of F varied with the flow. It was therefore fixed with a medium flow, and for smaller and larger flows there were small deflections on the galvanometer even when no heating current was applied. Before each reading it was therefore necessary to obtain the position of this false zero. The galvanometer connection was then transferred to H, and current passed through the heating grid and adjusted until the galvanometer needle returned to the false zero. As the voltage on the thermometers must be the same when the zero and when the reading is taken, it is necessary to connect them directly to the terminals of the battery supplying the current, and not to points of the heating circuit. The adjustment of the current is made by a sliding rheostat, and the voltage across the heating grid is measured by the voltmeter or the volt-thermometer, as the case may be, connected to the terminals J and K.

The connections of the volt-thermometer are shown in Fig. 2. LS and LT are a second pair of equal ratio arms. The fine platinum wire is represented by M, N is a balancing resistance coil, and PR a potentiometer. When a small voltage is applied, balance is obtained near to P, while with a large voltage the increase of resistance of M causes the balance point to be near R. The position of the balance point indicates the voltage applied.

Temperature Effect.—The amount of air flow is given by

$$W = \frac{V^2}{RSJ\,dT}.$$

The variation of S is known to be small over the range of temperature met with, and that of R was found by experiment to be also negligible. It remains to be ensured that V and dT are accurately measured at all temperatures. The rise in temperature dT is determined by the resistance of FH, Fig. 1, which does *not* represent the same increase in temperature at all temperatures for the two following reasons: (1) the resistance of FH itself varies with temperature; (2) the difference in the resistances of EC and BD for a difference in temperature of 1 deg. C. is not the same at all temperatures. The compensation for these variations can be provided by making FH of suitable material, as is shown as follows:—

The resistance of one of the thermometers is given by

$$R = R_0(1 + aT + bT^2),$$

where

R = Resistance at temperature T° C.
R_0 = " " " 0° C.

a and b are constants, and can be obtained by observations of the resistance at two temperatures in addition to observations at 0 deg. C.

$$dR = R_0(a + 2bT)\,dT.$$

For a given rise in temperature dT, the increase in resistance dR is thus not constant, but it must always be balanced by the same wire FH.

$$\text{Resistance of FH} = \tfrac{1}{2}dR = \tfrac{1}{2}R_0(a + 2bT)\,dT, = \tfrac{1}{2}R_0 a\left(1 + \frac{2b}{a}T\right)dT.$$

The resistance of FH at 0 deg. C. is therefore $\frac{1}{2}R_0 a\,dT$, and its temperature coefficient should be $2b/a$. By making FH from wire of two materials in suitable proportion it can be given any temperature coefficient.

The temperature effect on the reading of the voltage by means of the volt-thermometer may be considerable, but it can be eliminated for any given range of voltage and temperature with great accuracy. The platinum wire M, Fig. 2, is contained in a brass mounting at atmospheric temperature. When a current is passed through it, its temperature and resistance rises until the heat generated is balanced by the heat dissipated. For a given temperature difference between the wire and its surroundings, the same heat would be dissipated, but if the temperature and resistance of the wire in one case were different to those in another, there would not be the same heat generated. Hence the stationary temperature taken up depends on the atmospheric temperature. The resistances of N and PR are likewise affected by the temperature, and the net effect on the balance point can only be found by experiment. By making N of copper and manganin in correct proportion, it is possible to adjust the temperature effect

* Abstract of a paper read before the Institution of Mechanical Engineers on Friday, April 11, 1924.

so that it balances that of PR and M, and gives no resultant. By a combination of two materials in N it is only possible to obtain compensation for a limited range of voltage, the range being adjusted to suit that required in the experiments. If a large range of voltage is required in the tests, there may be a residual correction at each end of the scale amounting to, say, 1 per cent. for a temperature change of 15 deg. C. The compensation was made by calibrating the volt-thermometer when N (made wholly of manganin) and M were placed in a thin metal vessel first surrounded by ice and then by warm water. PR was made of alloy of negligible temperature coefficient. Part of the wire of N was then replaced by more and more copper until the calibrations at the two temperatures were practically identical over the desired range. If the circuits are thus accurately compensated, the reading of PR will give the air flow in grams per second without any correction for pressure and temperature variation.

Preliminary Experiments.—The first model was made for air consumptions up to 40 grams per second, which was suitable for engines up to 40 h.p. The body of the instrument consisted of a tube 3 in. in diameter and 4 in. long, fitted with conical ends which reduced the diameter to 2 in., that being the size of piping by which the air was led in and out. The electrical resistance of each thermometer at 0 deg. C. was 43·5 ohms, and that of the heating grid was 1 ohm. The current required for a range of air flows from 3 to 40 grams per second was 3 to 11 amperes, and it was supplied by a 12-volt starting battery. The rise in temperature used was 2·5 deg. C. Although in these tests any ordinary voltmeter could have been used to read the voltage, the instrument was made up with a volt-thermometer in order to obtain experience for the later models for aero-engines. The dimensions and arrangement of this model (tested on a Ford car) are shown in Figs. 3, 4 and 5, with the improved entrance later shown to be advisable, the method of construction being similar to that of the larger model described below.

Flowmeter for Aero Engine.—An instrument with a capacity range from 110 to 250 grams per second was constructed for experiments with a "Puma" engine in a D.H.9 machine. The body of the instrument was of brass and was 6 in. in diameter and 10 in. long. At the exit a cone reduced the diameter to 3·5 in. in order to connect to intake tubes of that diameter. A trumpet-shaped entrance was added to assist the formation of stable flow. One piece of fine gauze was fixed across the entrance to the cylindrical portion and five pieces across the wider part of the cone. A side tube in the 3·5-in. exit enables measurements to be made of the depression at that point. The heating element across the centre of the instrument consisted of three grids of "Climax" strip, mounted in three rings of fibre placed together and connected in parallel. The total resistance of the element was 0·333 ohm and was constant for all the air flows and currents used. The two electrical resistance thermometers, by means of which the rise in temperature was adjusted to constancy, were formed of single grids mounted in rings of fibre placed on each side of and 2 in. from the heating element, and were each made of about 6 metres of pure nickel wire of 0·004-in. diameter. The resistance of each at 0 deg. C. was 71·7 ohms. Nickel was used in preference to the more customary platinum because of its less cost, and also because the compensation of the temperature difference balance wire FH, Fig. 1, requires a balance wire of negative temperature coefficient in the case of platinum.

The balance wire FH was fixed to the outside of the flowmeter in order to be at the same temperature as the thermometers, a condition assumed in the method of temperature compensation. It was made of nickel and manganin in such proportions as to give it approximately the required coefficient, and when the coefficient was afterwards measured it was found that the possible error due to a temperature change from 20 deg. C. to − 10 deg. C. was only 1 part in 330. The whole resistance of FH corresponded to a difference of resistance between the two thermometers of 1·54 deg. C. The volt thermometer and the remaining parts of the circuits were fixed to an instrument board in front of the observer's seat. The four coils used for ratio arms were manganin of 100 ohms resistance. The wire M, Fig. 2, consisted of 5 mm. of very fine platinum wire fixed across a small closed tube and having a resistance of 180 ohms when the maximum voltage was applied. The potentiometer was of 40 ohms resistance, divided into 500 parts. The resistance of the coil N was 165 ohms, of which about one-tenth was copper and the rest manganin, the proportion being determined by trial and being adjusted so that the voltmeter gave the same reading on the potentiometer PR when a given voltage was applied to ST, whatever the temperature of the voltmeter. The rheostats were of the usual sliding type, one giving a rough adjustment and being made of four nichrome wires in parallel, and the other giving a fine adjustment and being made of two copper wires in parallel. The galvanometers were of the "Weston" portable type, having each a resistance of 250 ohms and giving a deflection of 1 mm. for 2 micro-amperes. The current was supplied by R.A.F., Mark III, 12-volt batteries.

Calibration with Steady and with Engine Flow.—The air flowmeter was calibrated by placing it in series with a large air-box and drawing air through them by means of a Roots blower. A large box intervened between blower and flowmeter to damp down any variations of velocity due to the action of the blower. The air entered the air-box through a number of sharp-edged orifices of 2 in. diameter, and left it through the flowmeter which was fixed to one side so that the trumpet-shaped entrance projected 2 in. into the air-box. The depression necessary to draw the air through the orifices was measured by an oil gauge which was found more satisfactory and steady than a water gauge. A calibration curve was plotted from 122 readings and was found to be very nearly a straight line.

After the flight tests the flowmeter and air-box were again connected in series, and attached to a "Puma" engine similar to that used in flight. The same tubes were used to connect the air flowmeter to the intakes of the two carburettors. Owing to the position in which the flowmeter had to be fixed upon the aeroplane, these tubes were much longer than was desirable, and conditions conducive to the formation of air vibrations in the pipes were thus produced. The presence of such vibrations was tested by a high-frequency rubber diaphragm gauge connected to a large side tube near the flowmeter exit. No measurable vibrations, however, were detected, and it was found that the readings of air-box and flowmeter agreed with the calibration obtained for steady flow with the blower. Tests were made both with full throttle at various speeds and at various throttles down to half power.

The observations made lie on the curve of calibration for steady flow with a similar number of positive and negative differences distributed irregularly along it, and only one point differs from the curve by 1 per cent. Thus with this six-cylinder engine and the connecting tubes used, the steady flow calibration holds good.

Horse-power and Air Consumption.—The brake horse-power obtained per gram of air per second lay between 1·080 and 1·070 for all points on full or slight throttle, but when the engine was severely throttled the value fell to 1·040. The conditions when an engine is throttled down to half power on the ground are not quite the same as those experienced when the power falls to one-half owing to altitude conditions, and further experiment is required on typical engines in an altitude test-house for a more exact determination of the relationship between brake horse-power of an aero engine and air consumption. If the frictional and pumping losses are obtained by motoring round and are added to the brake horse-power in order to obtain indicated horse-power then the indicated horse-power obtained per gram of air per second lies between 1·190 and 1·225. The whole differences found, together with possible differences due to altitude, are so small that if a mean value of the indicated horse-power per gram per second is taken and used under all conditions, while the frictional losses are assumed to be those obtained by motoring round, an estimate of the brake horse-power from the air consumption cannot be in error by more than 2 per cent. The assumption of proportionality between indicated horse-power and air consumption is sufficiently accurate for most purposes.

Flight Tests.—In the arrangements for attaching the flowmeter to the air intakes of the engine, the intakes of the two carburettors were joined by tubes 3·5 in. in diameter, which ran together in easy curves and both drew air from a single tube leading from the flowmeter. The tubular connections were rather long owing to the fact that there was no other place on the side of the machine to which the instrument could be so easily fixed. It was found, however, by attaching the diaphragm gauge when the engine was run up on the ground, that no air vibrations were formed in the flowmeter, a result confirmed by a similar test during the experiments upon the test-bed with the same connecting tubes and a similar engine. The entrance to the flowmeter was turned backward so that there was some depression there when the machine was in flight.

The extent of this depression, together with that due to frictional resistance inside the flowmeter, was measured during certain of the tests by means of a mercury gauge, one limb being connected to the static side of the air-speed indicator, and the other to a tube leading to the same point of the flowmeter that had been used for the diaphragm gauge. The effect of the total depression on the performance of the machine was found in a series of flights in which the air flowmeter was cut out and air entered from the side of the connecting tube. Experiments with level flights at 2,000 ft. and 8,000 ft., and with climbs between these heights, showed that the effect of the addition of the flowmeter and tubes was to reduce the revolutions per minute by only 10 revolutions and the air speed by 1 per cent.

It was found that the determinations could be made with the same ease as on the ground, and that the mechanical vibration of the galvanometer needles was very little greater than when used in the neighbourhood of the test-bed. With steady flight the balance could be adjusted with an accuracy corresponding to 1 part in 200. The conditions were considerably more steady than those experienced in the previous experiments on a Ford car.

Air Consumption at Altitude.—A continuous series of experiments was made and was repeated on subsequent days on the variation of air consumption at full throttle with altitude. The machine was first flown level at a height of about 2,000 ft. When the speed had become steady, readings were taken of the air and petrol consumption, revolutions per minute, air speed, highest temperature of radiator, temperature and pressure of the air. The carburation throughout was always such as to give a slightly rich mixture, so that the horse-power was determined by the air consumption. The process was then repeated at other altitudes up to 13,500 ft., beyond which the machine could only climb with extreme slowness. Readings were also taken during the downward journey. Readings of air consumption taken when the machine was run up on the ground were not very consistent, as it was not possible to run it at full throttle for sufficient time to obtain steady conditions. In flight the individual readings did not depart from the smoothed curve of a series of readings by more than 1 per cent., so that the curve should be accurate to 0·5 per cent.

From smoothed curves the values of the volumetric efficiency have been deduced E_1 in terms of the weight required to fill the stroke volume at N.T.P. and E_2 in terms of that required at intake density. As the observations are made at different revolutions per minute the value of E_2 at a uniform speed of 1,400 r.p.m. has been calculated by using the small variation found for the similar engine on the test-bed. The values of the efficiencies thus found at different altitudes are given in the following table :—

Volumetric Efficiencies at Altitude.

Aneroid Ht.	R.P.M.	E_1.	E_2.	E_2 (1,400).
Ft.		Per cent.	Per cent.	Per cent.
2,000	1,402	71·6	82·4	82·4
4,000	1,410	67·0	82·4	82·5
6,000	1,402	63·2	82·9	82·9
8,000	1,385	60·0	83·5	83·3
10,000	1,366	56·9	84·2	83·7
12,000	1,344	53·9	84·9	84·2
14,000	1,321	51·0	85·6	84·7

Thus the volumetric efficiency measured in terms of the air required at intake density and at constant revolutions per minute increases by 2 per cent. at an altitude of 14,000 ft. In other words, whereas the density fell to 68·5 per cent. of that at 2,000 ft., the weight of air taken per revolution at 1,400 r.p.m. only fell to 70·5 per cent.

Other Tests.—Many other determinations of air consumption under flight conditions were made, including comparison of level flights with climbs at the same altitude and at various altitudes. Readings were also taken on level flight when the engine was gradually throttled down, and the air consumptions compared with the corresponding air speeds of the machine. The particulars given in the annexed table

Air Consumption and Speed.

Height, 3,000 ft. Air density, 0·001125 gram per cm³.
Air temperature, 8 deg. C. Intake density, 0·001100 gram per cm³.

R.P.M.	Indicated Air Speed.	Radiator.	Air Petrol.	Air Consumption.
	M.P.H.	Degs. C.		Grams per Sec.
1,410	102	81	11·2	202·5
1,320	94	75	11·2	161·0
1,210	84·5	76	11·7	128·0
1,110	75·5	75	11·7	107·5
1,260	90	73	13·4	144·0
1,420	103	76	11·4	207·0

of one such test are quoted in order to show the consistency with which determinations can be made.

Conclusions.—The experiments showed that the calibration curve of the air flowmeter obtained with steady flow held good for the six cylinder "Puma"

36-FT. BORING AND TURNING MILL.

CONSTRUCTED BY THE JOHN BERTRAM AND SONS COMPANY, LIMITED, ENGINEERS, DUNDAS, ONTARIO.

engine, even with the long connecting tubes which the arrangements for the flight tests necessitated. For engines of lower speed and fewer cylinders, a damping air reservoir of small bulk only is needed even in extreme cases, to produce identity of steady flow and engine flow calibrations. The tests on the Ford car and on the D.H. 9 aeroplane showed that the instrument could be quickly and easily manipulated on the road and in flight, and that the curve of a series of readings should be accurate to 0·5 per cent. The air consumption of the aero-engine at full power and constant revolutions per minute fell off slightly less rapidly than the density in experiments at increasing altitude, and from throttling experiments on the ground it is deduced that the indicated horse-power up to 14,000 ft. is very nearly proportional to the density. With the data at present available a measure of the air consumption should give the brake horse-power with a possible error of less than 2 per cent. which could be reduced appreciably when more experiments have been made on the relationship between brake horse-power and air consumption.

36-FT. BORING AND TURNING MILL.

THE 36-ft. boring mill illustrated above is the product of the John Bertram and Sons Co., Limited, of Dundas, Ontario, and has been built owing to hydro-electric developments in Canada which have made it necessary for manufacturing companies to increase the size of their tools in order to deal effectively with the large units now employed. The firm of John Bertram and Sons is one of old standing, and its machines are to be found in all the chief works of Canada. Since 1905 it has been associated with the Niles-Bement-Pond Company and has thus had the advantage of a very wide and varied experience in machine tool construction.

The machine we illustrate has a swing of 36 ft. 2 in., taking work on the table 12 ft. in height, the boring bars having a feed of 8 ft. The table is 28 ft. in diameter. The crossrail casting and the casting for the top bridge are 47 ft. long and 4 ft. deep. The housing castings are 23 ft. 3 in. high and 10 ft. 2 in. from back to front at the foot. They are 30 in. wide at the base and have a width of vertical face of 24 in. In order to accommodate so large a tool in the works it was necessary to construct a concrete pit 8 ft. deep to secure head room under the cranes. The housings are rigidly connected at the top by a heavy cross girder, and a further structional steel girder extends between them at the back.

The table is deep and well ribbed and carried on two annular tracks of which that nearest the spindle is provided to eliminate sag in the table due to weight, compensation for wear being arranged for this bearing. The table spindle has a long split taper bushing, also to allow of adjustment for wear. The table has a large spur ring of 24 ft. pitch diameter, and it is driven by two pinions placed 25 ft. apart at the rear of the machine. The table top has parallel and radial slots. The crossrail is of the three-track type. Sliding supports are provided for the screws for traversing the saddles. The end thrust of these screws is taken up by ball bearings. The crossrail is of deep box section and extends back between the housings so as to secure great stiffness. It can be clamped to the front faces of the housings, and also locked to faces provided to the rear, on the inside of each housing casting. The clamping devices are operated by four small motors, controlled by one switch. Sagging of the crossrail is prevented by means of a deep cambered beam with three bearings and an adjusting screw. This beam extends the full distance between the housings. The crossrail is raised and lowered by four elevating screws taking the load on ball bearings. The drive for this is from a 30 h.p. motor on the top bridge, controlled by push-button starter.

The saddles have wide bearings with gibs for taking up wear. Clamping bolts are provided. Each saddle has an operator's platform, from which point the operator has full control of the machine. The boring bars are 15 ft. long, octagonal in shape, with 12-in. faces, and hollow bored. They can be set at any angle to the vertical within 45 deg. either side. Separate counterweights are furnished. The bars have a large number of feeds, which are reversible and independent for each saddle. Changes of feed are obtained by means of sliding gears in a gearbox. The box for each saddle is placed at the side of the mill. Rapid power traverse for the bars and saddles is obtained from a 10 h.p. motor on the top bridge, with push button control from the operator's platform and other stations. Safety friction clutches are incorporated in the drive, making damage practically impossible.

The main drive is by a direct-current variable speed 60 h.p. motor at the back of the machine. The drive is controlled by push-button from the saddles and from each side of the machine. Forced lubrication is provided for the table tracks and spindle. The main driving gears in the speed change box run in oil

HIGH ELASTIC LIMIT MILD STEEL AND ITS GENERAL APPLICATIONS.*

By G. W. BARR, Member, F. G. MARTIN, B.Sc., F.I.C., Associate, and A. T. WALL, A.R.C.Sc., O.B.E., Member.

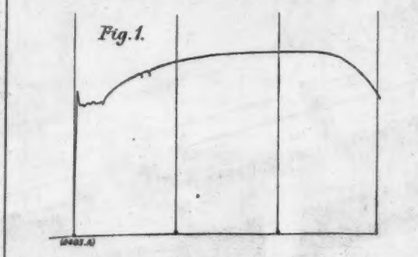
THE object of this paper is to describe a new mild steel which possesses a very high elastic limit, and to discuss in quite a general way some of its possibilities.

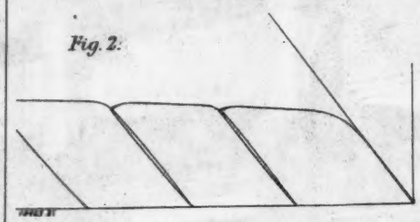
The replacement of iron by mild steel as a shipbuilding material is now looked upon as an event of the first importance, but it took some years to complete the change over. There were many doubts expressed during the transition period, as evidenced by the papers and discussions recorded in the Transactions of the Institution of Naval Architects. The great advantage claimed for mild steel, at the period when its advantages required advocacy, was its greater ultimate tensile stress, and little was said of its elastic limit. The value of its elastic limit was, however, taken to be near to the yield point, and the yield point was used, and, generally, is still so used, as a kind of commercial elastic limit. Recent investigations show that whatever might have been true in the earlier days of mild steel, the value of its elastic limit has for many years been considerably less than what is generally regarded as the yield point. The automatic load extension indicator introduced by Professor Dalby, and described before this Institution in 1912, has, with later modifications, made it possible to ascertain accurately and rapidly the elastic limit of a metal, and Professor Dalby is to be congratulated on his production. One of the authors, Mr. F. G. Martin, has carried out thousands of tests with this machine in the ordinary course of his work for the firm of shipowners by whom he is employed. It is found that the elastic limit of ordinary mild steel as used for ship construction is, and always has been, on an average about 8 tons per square inch. It sometimes, but infrequently, has a greater value, as much as 13 tons to 14 tons per square inch, although this is extremely rare; more often than it has these high values it has values as low as 3 tons to 4 tons per square inch.

Another point should be referred to in that the yield-point of ordinary mild steel may vary considerably, depending on the rapidity of the application of the load in the testing machine, and this irrespective of variation in the chemical and other properties of the metal. On the other hand, the elastic limit never varies except with change in the chemical and mechanical constitution of the metal. It has been demonstrated that there is absolutely no constant relation whatever between any two of the three things—elastic limit, yield-point, and ultimate stress. It has been the custom to carry out certain mechanical tests on ordinary mild steel intended for use in ships, and these tests have included ultimate stress, elongation, and bending. It has been the practice to assume that if these tests were satisfactorily passed the elastic limit would of necessity be inferentially guaranteed, and this elastic limit value has been assumed to be from 14 tons to 16 tons per square inch. As already remarked, tests on ordinary commercial mild steel show the elastic limit to be about 8 tons per square inch. Many hundreds of ships have been built of mild steel which has this elastic limit. Generally speaking, these vessels have given satisfaction, and the scantlings of the steel are standardized in the various rules of the Registration societies. It therefore appears reasonable to draw the conclusion that the present standard of strength set up for ships is such that the stresses in the ships do not exceed, at any rate, 8 tons per square inch. The probability is that this statement would meet with general acceptance, but few would be bold enough to give a definite figure for the actual stresses met with in ships. There is another reason for believing that these stresses are not large, and it arises from experimental tests on riveted joints. As a result of tests on an Admiralty-type treble-riveted butt-strap connection, it was found that the bead caulking of the butt opened enough for a feeler to be inserted at stresses of 3 tons to 4 tons per square inch. Further, Dr. Montgomerie's experiments on riveted lap joints would lead to the conclusion that the caulking of the lap must open up at quite small stresses similar to those just mentioned. In spite of this opening up of the caulking, riveted joints do not leak in practice except in special cases; and while this line of argument may be questioned by some, it does point to the fact that the stresses experienced in ships are not large. The experiments on the destroyer Wolf† indicate that the stresses in a ship are small, and less than those obtained by the usual standard calculations. The scantlings of ships have, so to speak, "grown up," but in recent years they have been modified and often redistributed by the application of comparative scientific methods, and the arrangement of the steel structure of ships is undoubtedly improving continuously in consequence.

NEW MILD STEEL.

There is now in existence a mild steel with a higher elastic limit than ordinary mild steel. Its full title is "a high elastic-limit mild steel," but for brevity it will be referred to as "elastic steel." This elastic steel is the development of Mr. F. G. Martin, a metallurgist of Liverpool, and one of the authors of this paper. This elastic steel has an elastic limit of 16 tons to 17 tons per square inch, as compared with 8 tons for ordinary mild steel. Its ultimate tensile stress is 30 tons to 35 tons per square inch, not very different from the 28 tons to 32 tons per square inch for ordinary mild steel. Its ductility is as good as that of ordinary mild steel, as evidenced by its elongation of 20 per cent in 8 in., and this is obviously an important attribute of it. The elastic steel is capable of withstanding continuous reversals of stress to a very much greater extent than ordinary rolled mild steel. It will withstand 10 million reversals at a stress equal to its elastic limit of, say, 16 tons, whereas ordinary mild steel will break down at about one million reversals at a stress equal to its elastic limit of 8 tons. The modulus of elasticity of the elastic steel is about 8 per cent. greater than that of ordinary mild steel. Its corrosive properties are the same as those of ordinary mild steel. It is precisely the same material to handle in a shipyard for all purposes as ordinary mild steel. In short, the only practical difference between it and mild steel is that its elastic limit is about twice as great, and its power to resist reversals of stresses more than twice as great, and, of course, its increased modulus of elasticity. The cost of this steel is about 25 per cent. greater than that of ordinary mild steel, but its price would drop as its use became extended, as was the case with ordinary mild steel.





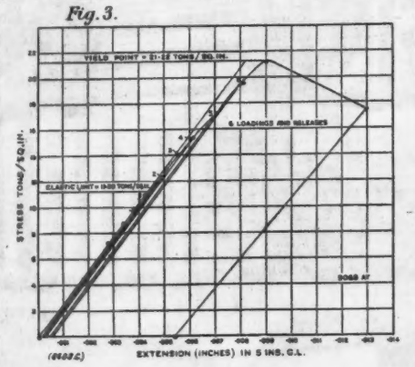


Fig. 3.
YIELD POINT = 21·12 TONS / SQ. IN.
6 LOADINGS AND RELEASES
ELASTIC LIMIT = 13·00 TONS/SQ. IN.
9068 AT
STRESS TONS/SQ.IN.
EXTENSION (INCHES) IN 5 INS. G.L.

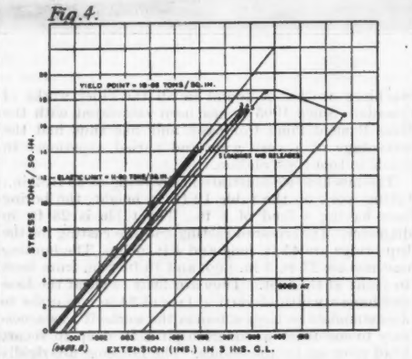


Fig. 4.
YIELD POINT = 16·06 TONS / SQ. IN.
3 LOADINGS AND RELEASES
ELASTIC LIMIT = 15·60 TONS/SQ.IN.
9069 AT
STRESS TONS/SQ. IN.
EXTENSION (INS.) IN 5 INS. G.L.

ELASTIC LIMIT AND YIELD-POINT.

Some load-strain diagrams of steel are reproduced in Figs. 1 and 2. Fig. 1 gives a load-strain curve showing yield-point, maximum and breaking loads, and elongation, while Fig. 2 shows a load-strain diagram on a greatly enlarged scale to facilitate the reading of the elastic limit. The diagram also shows the effect of stressing the material beyond the yield-point and then releasing the load, inducing permanent set. It will be seen that the stress-strain line is straight up to a certain point, which is the elastic limit. At this point there is a change in direction, and the line goes on more or less straight up to the yield-point, but with a greater slope than before. The Dalby Indicator gives the strain by the movements of a spot of light, and if the stress is released when it has a value below or up to the elastic limit, the spot of light will always return to zero. After the elastic limit is passed, the spot of light will not return to zero when the stress is released, indicating that permanent set has taken place in the material. Figs. 3 and 4 are copied from actual photographic records, obtained with a Dalby extensometer, and show the effect of applying and releasing stresses lying between the elastic limit and the yield-point. It is at once apparent that (1) loading a test bar to a stress lying between the elastic limit and the yield-point produces permanent set; (2) successive loadings to the *same stress*, if this is beyond the elastic limit, produce increasing permanent set.

It seems to be axiomatic that no stress in the ship structure should exceed the elastic limit of the material used, as otherwise permanent set will take place, and once this has occurred matters become serious. It would seem also to follow from this that the figure on which the factor of safety should be based is the elastic limit and not the yield-point or the ultimate stress. In the past, factors of safety have been expressed in terms of the ultimate stress, and this, of course, is quite satisfactory, provided the elastic limit of the mild steel bears a constant relation to the ultimate stress. In comparing two materials of the same ultimate stress, but one with a greater elastic limit than the other, it seems reasonable to allow a greater working stress in the material with the high elastic limit as compared with the other. This principle was enunciated by the celebrated Dr. Siemens, so far back as 1880, in the Transactions of this Institution for that year, pages 216 and 220. Dr. Siemens was using the argument to point out that there was no necessity to increase the ultimate tensile stress of steel if the elastic limit was not increased with it. In this connection, the use of high-tensile steel has not found so much favour in recent years—due, it is thought, to the fact that the elastic limit was not increased in the same proportion as the ultimate stress. It follows that when the new elastic steel is used in any structure it is permissible and sound policy to allow an increase in the direct tensile stress in the structure. Viewed from this standpoint alone, the direct tensile working stress may be doubled in the elastic steel compared with those in ordinary mild steel.

APPLICATIONS OF ELASTIC STEEL.

Stresses in a ship are produced in four principal ways:—(*a*) Longitudinal stresses: the main longitudinal stresses due to the straining action of a ship on waves and calculated in accordance with the established procedure. (*b*) Transverse stresses: the stresses due to transverse strains in which the frame and its proportionate amount of shell plating is considered as a girder. (*c*) Pressure stresses: the stresses due to water pressure and cargo or other loads on the plating. (*d*) Local stresses: the stresses due to slamming, panting, concentrated loads, machinery, &c. It will rarely, if ever, happen that any part of a ship's structure is at all times subjected to a pure tensile stress, but, dealing with the tensile stress only under the above headings, the following general remarks would apply:—From considerations under (*a*), since the form of the girder remains exactly the same, it only becomes necessary to reduce the thickness of the various plates and angles in the proportion of 1 to 2. From considerations under (*b*), the reduction in thickness of the shell plating brought about by considerations under (*a*), (*c*), and (*d*), will reduce the transverse strength, and it would remain to adjust the size of the framing, so that the transverse tensile stresses are reduced in the ratio of 1 to 2. From considerations under (*c*) it has now been sufficiently demonstrated that the stresses in the shell plating due to water pressure or uniform

* Paper read at the Spring Meetings of the Institution of Naval Architects, April 11, 1924.

† See Trans. I.N.A., vol. xlvii, Part I, page 80.

loading of cargo varies inversely as the square of the thickness of the plating, and in considering these stresses, the thickness of the plating would be reduced in the ratio of 1 to the square root of 2. From considerations under (*d*), special and local stiffening would still have to be fitted to meet these stresses, but the scantlings can be reduced in the same considerations as apply under (*c*). It is not proposed to attempt to give in this paper any details with regard to actual reduction in scantlings that would be possible. It is necessary to work these out very carefully in the different parts of the structure, so that in some cases the possible reduction in scantlings would be greater than in others. This would form subject-matter for more than one additional paper.

With regard to compressive stresses, failure under compression occurs by secondary flexure or buckling, and this kind of failure is difficult to treat with exactitude. It is true to say that failure by secondary flexure is failure due to shear, and the new elastic steel has an improved elastic limit for shear stress. Dr. Montgomerie, however, has given a lead in this connection in a paper in Stress Determination in Flat Steel Plates, read before this Institution in 1919.* In this paper he said that the plating of a ship can transmit compressive stresses of considerable magnitude at much wider spaces than are adopted in a ship. It is also true that since the thickness of the longitudinal material cannot be reduced in the inverse proportion of the elastic limits when viewed from the standpoint of longitudinal stresses alone, there is something in hand to set off against an increased compressive stress. In any case, increased compressive stresses can be readily carried by flat plating, provided it is given sufficient stiffening. There should be no fear, within reasonable limits, of the failure due to compression in the bottom shell plating, which is very well stiffened under present methods of construction. The plating of the top deck amidships might require additional stiffening to resist compressive stresses, as is the case in many ships to-day. This would be a good thing to do and should take the form of longitudinal stiffening, when all fear of failure by secondary flexure under compression would disappear. This matter would require careful attention, but there is no doubt that a reduction of scantlings would be possible. No good purpose would be served by elaborating this matter of the actual reduction in scantlings any further, as it would introduce a long detailed account which is not intended for this paper.

JOINTS.

Some remarks should be made on the method of jointing the new elastic steel. While elastic steel has a greater elastic limit than the old steel, the same is not true of the riveted connections if they are constructed in accordance with present practice. It is now generally accepted that a riveted joint slips under stress, but that it will recover itself if the stress does not exceed a certain amount. Dr. Montgomerie has done valuable work on this matter, and his conclusion is that the elastic slip limit of a riveted joint is a stress generally commensurate with the working stresses in the material. If the riveted joints with the elastic steel were made in accordance with the practice for ordinary mild steel there would be no increase in the elastic slip value of the riveted joints, whereas it should be increased to be commensurate with the increased stresses in the elastic steel. Dr. Montgomerie's conclusions are also that the total elastic slip value of a riveted joint varies directly as the product of the number of rivets and the square of the diameter of each rivet. This would necessitate an increase of riveting, which increase would depend on the position of the joint in the structure. Whether the stronger riveted joints, subjected to greater unit stresses, would be satisfactory is a matter for experiment with regard to some parts of the structure, and such experiments are to be carried out. In the majority of places a direct increase from, say, double to treble, or treble to quadruple-riveted joints will meet the case. Arising out of this, it seems self-evident that joints electrically welded and giving 100 per cent. efficiency would be the ideal method to use, and circumstances strongly favour electric welding. The steel scantlings for an existing vessel 450 ft. long, built of ordinary mild steel, have been examined in some detail, and modified scantlings drawn up for the new elastic steel. It was found that erring very much on the side of safety for the new elastic steel, it was possible to effect a saving of 12½ per cent. in the steel weight, or a saving of 400 tons in the weight of the light ship, giving that much gain in the deadweight-carrying capacity of the ship. It was also estimated that the increase in the total cost of the ship would not exceed 3 to 4 per cent., which would be easily set off by the additional earnings of the increased deadweight capacity. For bridge construction the new steel will be invaluable, when it is remembered that by far the greater proportion of the steelwork must be fitted to carry its own weight, and only a small proportion is required to carry the load. The matter of the application of this new elastic steel to the construction of a ship has now reached a very definite stage, so much so that a vessel will shortly be constructed of the new material, and it seems that the changes from ordinary mild steel to the new high elastic limit mild steel should have far-reaching consequences.

* Trans. I.N.A., vol. lxi, page 281.

BARTON AND DALMARNOCK POWER-STATIONS.*

"THE BARTON POWER-STATION OF THE MANCHESTER CORPORATION, AND THE TRANSMISSION-SYSTEM IN CONNECTION THEREWITH."

By HENRY NEWMARCH ALLOTT, M.Inst.C.E., and STANDEN LEONARD PEARCE, C.B.E., M.Inst.C.E.

THE Barton power-station is the fourth to be built by the Manchester Corporation. Designs were completed in 1914, but progress of work was interrupted by the war, and plant was installed at the Stuart-street Station, bringing the total capacity of the system up to 126,750 kw. Work on the new station was actually commenced in April, 1920. The site, containing 14¼ acres, is in Trafford Park, in close proximity to the Manchester Ship Canal. Within the limits available, the condensing water will be drawn from the Ship Canal, with the sewage and subsoil water from the Davyhulme sewage works as a future additional source of supply. The site can accommodate about 165,000 kw. of plant, whereof the first section consists of 82,500 kw. Red sandstone rock underlies the whole site. Foundation work, therefore, did not present any special difficulty.

A comprehensive system of railways was laid down on the site, to facilitate the handling of materials, and a temporary substation was erected for the supply of energy for driving the contractors' plant. A road bisected the site, and necessitated the construction of a new road and bridge over the Bridgewater Canal. The road bridge also carries a single line of railway for the Trafford Park Estates Company, and will carry a load of 72 tons. A double-track railway bridge has also been constructed for rail-borne coal traffic to the station. A coaling dock, with a lay-by, has been provided for dealing with canal-borne coal from the Bridgewater Canal. The docks are each 50 ft. wide and 320 ft. and 250 ft. long, respectively.

The buildings, generally, are of steel-frame construction, the walls being of brick and the floors of concrete. The roofs are of girder construction, covered with reinforced concrete slabs, and fitted with lanterns for lighting and ventilation. The office building abuts on to the end wall of the turbine house, and is of reinforced concrete. The basement of the boiler house is at ground level, the firing floor being placed at a height of 18 ft. The floor carrying the draught plant, &c., in connection with the boilers is 43 ft. above the firing floor. There are two firing passages, and above each are the reinforced concrete bunkers. The turbine house has a basement 25 ft. deep for the condensing plant. The circulating-water pump house forms part of the turbine-house basement, and the floor is about 36 ft. below ground-level. The main switch and transformer house is a separate, three-storey building. The bottom floor contains the step-up transformers, oil-cooling plant, and 6,600-volt switchgear; the busbars and oil switches are installed on the first and second floors respectively.

The inlet chamber for the circulating-water system is constructed of concrete, the bottom being 50 ft. below ground-level. The water is drawn through three canals, each fitted with a grid screen and travelling perforated band screen, with penstocks for shutting off the water when required. The inlet chamber, pump-house sump, and outlet chamber are connected by culverts 9 ft. 6 in. in diameter, about 50 ft. below ground-level, the total length being about 2,400 ft. Six electrically driven pumps are installed, two for each main condenser. The pumps, being below the water-level of the Manchester Ship Canal, are constantly flooded. The outlet chamber is 100 ft. long by 21 ft. wide. A mid-rib extends the whole length of the chamber, serving to distribute the flow, and acting as a measuring-weir. The water is discharged to the canal through ten openings at the bottom of the outer wall.

Storage is provided in silos for about 22,500 tons of fuel. Rail-borne fuel is delivered into hoppers on the viaduct. Bucket-type conveyors transfer the coal either direct to the bunkers or to the silos, for storage. They can also take coal from the silos to the bunkers. Canal-borne fuel is unloaded from the barges by means of two overhead travelling cranes, which can discharge the coal to the conveyors, to be deposited either in the coal bunkers or in the silos.

There are nine double-fired boilers of the marine type, each capable of evaporating 100,000 lb. of water per hour, actual, at their most efficient rating. They are designed to evaporate 120,000 lb. of water per hour during overload periods. Each boiler, with its stokers, superheaters, economisers, air-heaters, forced and induced draught fans, and chimney, is a complete unit in itself. The ashes are discharged into hoppers underneath the boilers. Standard-gauge railway wagons and road-transport wagons can be filled direct from these hoppers, thus dispensing with suction ash plants or ash conveyors. The feed-pipes have bolted joints, and the steam-pipe joints are riveted, no jointing material being used in either case.

The first section of the station contains three 27,500-kw. turbo-alternators, each capable of giving an output of 31,250 kw. for a period of two hours. The condensers are of the contra-flow surface type, each set having "kinetic" and steam-jet extraction plants. The normal conditions for which the sets are designed are: steam-pressure, 350 lb. per sq. in. (gauge); steam-temperature, 700 deg. F.; vacuum, 29·1 in.; voltage, 6,600; and speed, 1,500 r.p.m. Power for the station auxiliaries is furnished in part by three 420-volt house-service turbo-alternators. These sets are designed for the same steam-pressure and temperature as the main sets, and run at a speed of 3,000 r.p.m. Each alternator is ventilated on the closed-air-circuit principle. All the station auxiliaries, with the exception of three stand-by turbine-driven feed pumps, are electrically driven by 420-volt, a.-c. motors, the load being distributed between the house-service alternators and three house-service transformers supplied from the 33,000-volt busbars.

Each main alternator is coupled direct to two three-phase transformers, each of 19,500-kva. capacity, which step up the pressure from 6,600 volts to 33,000 volts. The transformers are of the forced-oil-cooled type, each having its own oil-cooling equipment. The switchgear is laid out to control generating plant of 100,000-kw. capacity, interconnected with a future station of the same size and to existing stations. The circuits are divided into three groups, each comprising a main alternator, a house-service transformer and three or four feeders. These circuits are connected to duplicate busbars. A tie busbar is also employed, to which the main busbar is connected through reactors. The switchgear is of the cellular type.

Energy is transmitted from the Barton power-station into the Manchester area, also to the Lancashire Electric Power Company's and the Stretford Urban District Council's systems, by means of 0·3 sq. in., 3-core, 33,000-volt cables, laid direct in the ground.

Five substations have been built in the Manchester area, namely, Stuart-street, Oldham-road, Moss Side, Dickinson-street and High-street. Outgoing feeders from one or other of these centres continue the 33,000-volt supply to Middleton, Droylsden, Failsworth and Salford. The buildings are all of brick. The switchgear in four of the substations is of the armour-clad type, manufactured by two different firms. High-street substation is the first example of a large 33,000-volt outdoor substation in this country. There are seven 33,000-volt switchgear equipments, mounted on a reinforced concrete structure. Mechanical gear has been fitted for operating the isolating links from ground-level. The oil switches are of the tank type and are remote electrically controlled. Three 8,500-kva. single-phase, outdoor transformer groups are also installed. Each transformer group is connected to induction type voltage regulators. The 6,600-volt switchgear in this substation is of the cellular type. The switchgear at the Dickinson-street substation is of a new type, with duplicate busbars. Each equipment comprises two oil switches in one tank. These are remote electrically controlled.

* Abstracts of papers read before the Institution of Civil Engineers on Tuesday, April 15, 1924.

"DALMARNOCK ELECTRICITY WORKS."

By WILLIAM BURNSIDE, Assoc.M.Inst.C.E.

Dalmarnock Electricity Works of Glasgow Corporation Electricity Department have a present capacity of 75,000 kw. economical rating, with provision for a similar extension. Coal fuel is used. Steam is generated at a pressure of 275 lb. per sq. in. by gauge and at a total temperature of 700 deg. F. Current is generated at 6,500 volts, three-phase, 25 periods, and transformed to 20,000 volts for transmission.

Ideally, the site of a central station should be at the load-centre of the area, and in close proximity to the coal supply, with good transit facilities between; it should be contiguous to an ample supply of condenser cooling water; and the ground should be of sufficient area, and suitable for foundations. Actually, the determining and limiting factor is the supply of cooling water. The quantity required per Board of Trade unit for an efficient plant is about 90 gal., and for the complete Dalmarnock station about 14,000,000 gal. per hour will be required. This water must be free from suspended matter, and the provision and screening of

it forms one of the most serious problems in design at the present time.

About 700 tons of coal and about 9,000 tons of air for combustion per 24 hours are required for the present plant on a 50 per cent. load factor, the resulting ash being about 100 tons, and the make-up feed water for the same duty about 150 tons. The purifying of the make-up and the de-aeration of the whole feed water are other troublesome problems.

All these materials—coal, water, air, ash—have to be handled and properly distributed and disposed. In addition, two months' to three months' supply of coal has to be stored and reclaimed. The load diversity demands flexibility in the plant, which is met to some extent by the range of the units, but principally by the unit subdivision. Sets of 15,000 kw. to 20,000 kw. are efficient units and are quite suitable for manipulating the load on large stations. If one unit of half size is installed, a finer adjustment of plant to load is possible. Plant must be provided for extreme conditions, plus an excess of about 20 per cent. for overhauling and repairs. The general aim in design is to obtain the highest possible efficiency consistent with reliability. Duplication of auxiliaries and automatic protection of conductors help to secure reliability.

Ground and Buildings.—The ground at Dalmarnock, about 13¼ acres, is on the right bank of the Clyde, at the eastern boundary of the city. An additional 4 acres has been acquired recently for railway sidings. The surface ground, 4 ft. to 12 ft. in depth, is of tipped material. Below, there is fresh-water alluvium of a former course of the river, overlying Permian sandstone about 50 ft. to 80 ft. below the artificial surface. The strata—clay, sand and gravel—are mostly soft, and spread foundations, reinforced with steel under heavy point loads, were adopted. The maximum load on the ground is about 1¼ tons per sq. ft. The subsurface works, consisting of water intakes and culverts, foundations, coal-filler pits, and pump chambers, are in concrete, plain and reinforced. With the exception of the roof of the turbine-house, which is of steel, the structural members of the buildings and coal tanks are of reinforced concrete, with brickwork side, end, and division walls. The percentage areas occupied by the various parts are as follows :—

	At Present.	Completed.
Water intakes and culverts	3·50	4·25
Coal store	22·00	22·00
Boiler houses	4·75	10·00
Turbine house	3·75	7·00
Switch house, &c.	1·50	2·50
Store, substation, &c.	1·50	1·50
Railway sidings and yards	63·00	52·75
	100·00	100·00

Water Intakes and Culverts.—Two intakes from the river have been constructed, and a third is in course of construction. The water is controlled by sluices and cleaned on moving screens. The inlet culvert, into which the branches from the screens discharge, is alongside the river side of the turbine house; and the discharge is alongside the farther wall under the boiler houses for part of its length, and discharges into the river 350 ft. below the nearest intake.

Coal Store and Coal Handling.—The store is enclosed by reinforced concrete retaining walls and has a capacity of about 70,000 tons. It is commanded by a travelling transporter of 190-ft. span, running on one wall and on a gantry near the other, or outer, wall. The transporter carries a gravity bucket conveyor for storing, and a travelling crab with four-rope grab for reclaiming the coal. The coal-handling plant generally is of conveyor type, both gravity bucket and tray. Coal can be taken (1) from filler pits to boiler-house tanks, (2) from filler pits to store, (3) from store to boiler-house tanks.

Boiler Houses.—The two boiler houses abut on the turbine house at right angles. Each is 80 ft. wide and 149 ft. long, with three floors—a basement at yard level on which forced-draught plant and ash-hoppers are situated; firing floor, 15 ft. above the basement; and economiser floor, 29 ft. 6 in. higher. There is a row of four boilers on each side of each firing floor. The boilers have each a normal capacity of 50,000 lb. of water evaporated per hour with feed water at 150 deg. F. The stokers are of chain-grate type and both forced- and induced-draught plant are provided. The furnace gases are passed through economisers to steel chimneys lined with cement plaster on "hy-rib." There is one chimney, 9½ ft. diameter, and one induced-draught fan to each two boilers, and a forced-draught fan to each boiler. There are two feed pumps to each line of four boilers. They form duplicates, and have each a capacity of 20,000 gal. per hour against a total head of 340 lb. per sq. in. One pump is a steam centrifugal, and the other a motor-driven multi-stage centrifugal. Suction ash and soot plant is installed.

Turbine House.—The turbine house is 75 ft. clear between columns, 230 ft. long, and is commanded by a 75-ton overhead electric travelling crane. The condenser on the basement floor is 11 ft. below yard-level; the turbine floor is 26 ft., and the crane-rail level 54 ft., above the basement.

There are five 15,000-kw., 1,500-r.p.m. turbo-alternator sets placed transversely at 40-ft. centres. The turbines are designed for steam at 250 lb. per sq. in. by gauge, and 650 deg. F.; vacuum, 29·1 in. with barometer at 30 in. Surface condensers are bolted to the turbine exhaust, each having a condensing area of 26,000 sq. ft. and a capacity of 160,000 lb. to 200,000 lb. of steam per hour. There is a 36-in. horizontal centrifugal circulating water pump to each set. Motor-driven and ejector auxiliaries are installed in different machines. The alternators are coupled direct to the turbines. They are of two-pole type, rated at 18,750 kw. at 0·8 power factor. Each requires 70,000 cu. ft. of air per minute for ventilation, which is cleaned and cooled by wet-air filters—two to each machine.

Switch House, &c.—The switch house is alongside the turbine house, 30 ft. distant. There are three single-phase oil-cooled transformers to each generating set, on the lower floor. The high-tension switchgear, of oil-immersed iron-clad type, is on the upper floor. The control room is at one end, and switch operation is by solenoid operated from the control room.

Auxiliary Services.—With the exception of the turbine feed pumps, all the auxiliaries are motor-driven. The current is 440 volts, three-phase, 25 periods, from various sources—two house turbo-generators, two house transformers, 20,000/440 volts, and tappings in three machines from low-tension windings on the step-up transformers. The condensate, on its way back to the boilers as feed water, is heated in various ways and enters the drums at a temperature of about 270 deg. F. The two house turbines exhaust into open-type heaters through which the condensate is passed; the steam from the condenser steam ejectors is dealt with similarly; steam is bled from turbines Nos. 2 to 5 for low-pressure heaters, and the exhaust from turbine pumps is discharged through nozzles into the hot wells.

Working Results and Costs.—The working results have been very satisfactory, and, in spite of a load-factor of only about 34 per cent., are among the best in the country. The quantity of coal used per unit generated is generally about 1·78 lb., and the thermal efficiency is about 18 per cent. The capital cost up to May 31, 1923, was £1,903,649, made up as follows :—

	£	Per Cent.
Land	72,807	3·8
Buildings	511,381	26·8
Electrical plant	417,977	21·9
Steam plant	819,476	43·1
Coal and ash-handling plant	51,739	2·8
Cranes	24,525	1·2
Accumulators	5,744	0·4
	1,903,649	100·0

The works were designed and carried out under the supervision of the engineering staff of the department, first under Mr. W. W. Lackie, C.B.E., M.Inst.C.E., now one of H.M. Electricity Commissioners, and afterwards under Mr. R. B. Mitchell, the present Chief Engineer.

NOTCHED-BAR IMPACT TESTS.—Discussing the theory and practice of notched-bar impact tests, Professor Paul Fillunger, of Vienna points out in a recent paper that the principle of similarity is never strictly applicable to large and small test specimens, especially not with brittle materials. Among the possible sources of error in the tests he mentions friction. Polishing or greasing the specimen and its mounting and also the face of the striking hammer, he found that the work done in fracture was, by this preparation, reduced by about 7 per cent. His experiments were made with various sheets, wrought iron, rolled copper and cast aluminium, the specimens being provided with the usual cut and drilled notches, with sharp V-notches and with grooves, semi-circular or of area larger or smaller than semi-circles. Referring the work done in fracture ϵ to the unit area of cross-section at the bottom of the notch, he concludes that ϵ would increase with the radius of curvature of the notch, all other dimensions remaining unchanged, and would increase also for the same radius of curvature, with decreasing depth of the notch. For geometrically similar specimens the ϵ would increase with l^n, where l was the length of the specimen and n was intermediate between 2 and 3. The general relation would be $\epsilon = \delta_y + 2w$ where y was the eccentricity depending upon the radius of curvature, and δ and $2w$ represented brittleness and "fissility," or the reciprocals of the resistance to fracture and to splitting. Two components of this type had previously been distinguished by French investigators, and Föppl similarly distinguishes in the testing of stones, between the work which would crush a stone at a single blow, and the smaller work which the stone could resist in repeated blows, the former would correspond to δ, the latter to $2w$. Fillunger, moreover, points out that the hyperbolic curves which Stanton and Batson obtained in their investigations of the influence on the test results of the dimensions of geometrically-similar specimens would conform to his formula for ϵ.

CATALOGUES.

Pipe Fittings.—An extensive range of pipe fittings, valves, and tools required for pipe work is presented in a strongly-bound catalogue issued by Messrs. Crane-Bennett, Limited, 45, Leman-street, London, E.1. The catalogue is divided into five sections dealing with malleable-iron and cast-iron fittings; hangers, brackets, &c.; valves, cocks and special fittings; ammonia valves and fittings; and tools. Each article is illustrated and a table of sizes and prices is given. There is also a section giving the technical information and data most frequently required.

Switchgear.—A new catalogue of iron-clad truck-type switchboards for alternating-current systems with working pressures ranging from 660 volts to 11,000 volts has been issued by the English Electric Company, Limited, Queen's House, Kingsway, London, W.C. 2. A truck mounted on four wheels carries the whole of the apparatus for each circuit, and the truck is easily and safely withdrawn from, or returned to, the built-up switchboard of which it forms a unit. No castings are used in the construction of the frame, so that the risk of breakage is much reduced.

Grain Milling Equipment.—Messrs. Henry Simon, Limited, 20, Mount-street, Manchester, have sent us a copy of a pamphlet illustrating and describing mill construction and equipment work in hand or completed by them. Among the items are included a silo and flour mill at Port Elizabeth, South Africa, complete with elevating, cleaning, grinding, and all necessary machinery; bins constructed at Cape Town for 30,000 tons of maize; and a pneumatic plant for the Great Western Railway Company's service at Cardiff for handling 120 tons of wheat per hour. The last-mentioned plant is built into a pontoon which can be moved from one dock to another.

Mixing Machines.—Mixing machines for the chemical trades form the subject of a special catalogue issued by Messrs. W. J. Fraser and Co., Limited, Dagenham, Essex. The standard mixers, which are made with capacities ranging from half a gallon to 5,000 gallons, have vertical mixing spindles and horizontal driving shafts and are fitted for gas, steam or oil-bath heating as required. If desired, the heating casings, &c., may be interchangeable. The pan is closed or open, and is suitable for either pressure or vacuum. Particulars of about twenty special types are given, including those for acids, greases, dry powdered materials, &c. Various forms of stirring appliances are employed.

Steel.—Messrs. Edgar Allen and Co., Limited, Sheffield, have issued a book of 96 pages specially compiled for the use of purchasers of steel, and including prices, lists of extras and other information necessary for persons issuing orders or making inquiries for this material. A few pages on the choice of tool steels is followed by sections relating to high-speed steels, special alloy tool steels, plain carbon tool steels, mining steels, steel tools and steel forgings; each section has its own table of contents, in order to facilitate reference. The list of tools ready for use is extensive and each tool is illustrated and accompanied by a table of sizes, prices, &c. Buyers will doubtless find this publication of considerable assistance in specifying their exact requirements.

Portable Steam Engines.—A catalogue issued by Messrs. Robey and Co., Limited, Lincoln, one of the largest manufacturers of portable and semi-portable steam engines, illustrates a variety both of types and sizes of these engines, all of which are made to standard dimensions. Single-expansion engines are made with either one or two cylinders and the compound engines are provided with inter-heaters between the high-pressure and low-pressure cylinders. The effective horse-powers of engines included in the lists range from 5 to 150 at economical loads, all sizes being capable of developing much larger powers with slightly reduced economy. In some cases the engine may be enclosed and the boilers adapted for wood fuel. The catalogue contains a brief description of the main parts and complete tables of powers, dimensions, weights, &c.

ELECTRICAL MACHINERY IMPORTS IN GUATEMALA.—A table prepared by the Department of Overseas Trade gives the following figures for the imports of electrical machinery, material and appliances in Guatemala :—

	1920.	1921.	1922.	1923.
	In Kilogrammes.			
From—				
Germany ...	5,654	55,275	64,098	258,025
The United States ...	274,727	376,537	76,697	391,922
Other countries	1,031	—	603	3,182
	By Values, in United States Currency.			
	1920. Dols.	1921. Dols.	1922. Dols.	1923. Dols.
From—				
Germany ...	4,855	27,474	17,370	76,296
The United States ...	125,210	221,972	39,085	129,024
Other countries	1,268	—	2,450	5,186

The imports consist chiefly of motors, dynamos, incandescent lamps, wire, telephones, batteries, light fittings, heaters, &c. Sales, as regards Guatemala city, are limited by the available power, and will probably increase after the completion, next August, of the plant at San Luis. The future is promising for the development of hydro-electric installations.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 1s.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

MACHINE AND OTHER TOOLS, SHAFTING, &c.

209,282. George Taylor (Brass Founders), Limited, Bolton, and J. R. Tate, Bolton. Guards or Shields for Rotating Shafts. (3 *Figs.*) December 21, 1922.—The invention relates to shaft guards or shields as employed in textile and other machinery to prevent entanglement of the cloth and the risk of injury to the operatives or attendants. The invention comprises a segmental sleeve of metal, papier-mâché or other material and segmental end collars or sockets adapted to secure the sleeve segments together and to provide bearings or journal boxes whereby the complete device is freely mounted or supported on the shaft. The guard is made up from a pair of semi-circular sleeve parts *a* and a pair of semicircular collar parts *b* for each

Fig. 1.

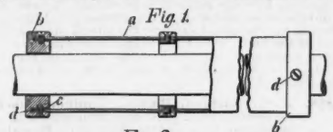
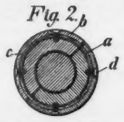


Fig. 2.



end of the sleeve. The collar parts have an annular groove or channel *c* cut therein from the inner side to receive the respective ends of the sleeve parts. The respective parts are so placed or assembled upon the shaft that the joints or meeting edges of the sleeve parts are at right angles to the joints or edges of the collar parts, each collar part being thus caused to extend over both segments of the sleeve. When so placed in position upon or around the shaft, the parts are all secured together to form a unit, which is free on the shaft, by means of screws *d* fitted in the collar parts and engaging or passing through apertures in the sleeve parts. The complete sleeve is supported on the shaft by the contact therewith of the end collars. (*Sealed.*)

MINING, METALLURGY AND METAL WORKING.

209,458. H. J. Toogood, Elland, and Robert Dempster and Sons, Limited, Elland. Regenerator Furnaces. (4 *Figs.*) September 13, 1922.—The invention relates to regenerator furnaces such as are used in connection with gas retorts. According to the improved arrangement, the regenerator is constructed of staggered vertical tubes of extra large cross-sectional area both

Fig. 1.

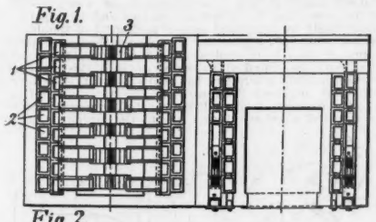
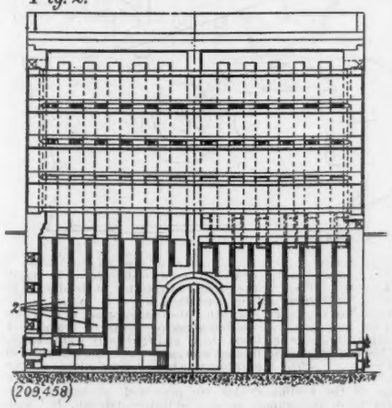


Fig. 2.

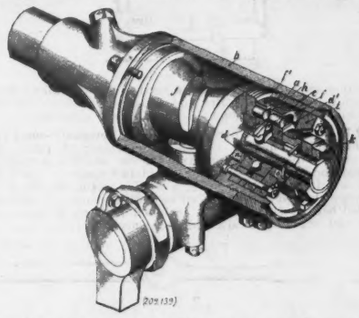


(209,458)

for waste heat and for secondary air. 1 indicates the secondary air tubes and 2 the waste-heat tubes. These tubes are staggered in relation to each other as shown so that the horizontal and vertical joints of each tube are covered by the wall of the other tube. The tubes are built back to back so that a two-ply partition divides the descending waste heat and the ascending secondary air; thus the tightest and thinnest dividing wall is arrived at for high rate of transmission of heat and any crack which might develop with age in one tube is opposed by the wall of the adjacent tube and the high efficiency of heat transmission remains unimpaired through the life of the regenerator. The regenerator tubes occupy the full depth of heated brickwork available so as to produce a chimney effect in the hot secondary air tubes 1 which is sufficient to cause the column of secondary air within the regenerator to rise directly into the combustion chamber 3, even though there may be a slight plus pressure in the latter. (*Accepted January 23, 1924.*)

MOTOR ROAD VEHICLES.

209,139. The Maries Steering Company, Limited, London, H. W. Egerton, London, and R. Bishop, London. Steering Gear. (4 *Figs.*) September 8, 1922.—According to the chief feature of the invention, the ball thrust bearings in connection with the steering column are arranged in a single self-contained unit to take the thrusts in both directions. The thrust unit comprises a hollow cylindrical housing *a* screwed into the casing *b* of the steering gear. Mounted concentrically within the housing *a* is a pair of ball thrust washers *d*, *d*1 having component ball grooves on their adjacent side faces in which a circular row of balls *e* is arranged. Between the outer peripheries of the washers *d*, *d*1, which also form the inner rings of a pair of free wheel clutches, and the inner surface of the housing *a* is arranged a pair of outer free wheel clutch rings *f*, *f*1, which are bolted to the housing *a* together with an intermediate spacing ring *h* and an outer retaining ring *i*. The ring *i* screws into the housing *a* and co-operates with a flange on the other side of the



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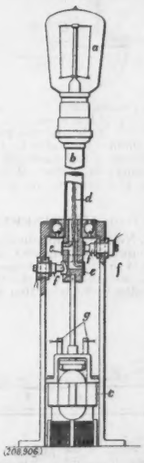
housing *a* to hold loosely the members *d*, *d*1 of the free wheel clutch in place. The members *f*, *f*1 of the free wheel clutches are arranged in reverse order, so that one ring *d* can revolve only in one direction and one *d*1 only in the other direction. The thrust unit is screwed into the casing *b* below the cam *j* and is secured to the cam by means of a shank *k* over which the unit is passed and on which it is fixed by means of a nut. A plain thrust ring *n* is provided between the cam *j* and the thrust unit on one side and a keyed and spring-pressed thrust ring *o* on the other side so that frictional contact is made with the sides of the free wheel clutch rings *d*, *d*1. One of the thrust rings *d* is held from rotation in one direction and the arrangement is such that when the cam *j* is being turned by the steering wheel the ball bearing surfaces and balls *e* will be in operation, whereas should movement be transmitted from the steering road wheels, the plain frictional surfaces on the side faces of the rings *d* or *d*1 will come into operation. (*Sealed.*)

SHIPS AND NAUTICAL APPLIANCES.

208,906. H. J. S. Stobart, Smethwick, and G. T. Lane, Smethwick. Navigation Lights. (1 *Fig.*) December 20, 1922.—The invention relates to navigation lights such as those arranged on lighthouses, harbour lights and the like in which a revolving dioptric system is used in conjunction with a source of illumination. The object of the invention is to enable a beam of approximately uniform intensity to be obtained from an electric incandescent filament bulb of ordinary construction, and this result is attained, in accordance with the invention, by revolv-



(208,906)

ing the bulb. In carrying the invention into effect, a rotation relatively to the light projecting system is imparted to the bulb, and the rate of rotation is made such that the appearance of fluctuating brightness in each flash is avoided. The incandescent filament bulb *a* is carried at the upper end of a vertical stem *b*, which is rotated by an electric motor *c* contained in the base of the apparatus. Current is conveyed to and from the bulb by conductors *d* connected to slip rings *e* which act with stationary brushes *f*. Supply of current to the motor is effected at the terminals *g*. (*Sealed.*)

208,938. T. Clarke, Londonderry, W. Christie, Glasgow, and B. W. Johnston, Sunderland. Cleats or Brackets for Ships' Cargo Battens. (6 *Figs.*) January 24, 1923.—The invention relates to cleats of the type having a hook which is passed through a hole in the supporting frame and a tail which engages the front edge of the frame, the hook and tail serving to keep the cleat rigidly in position when the batten is in place. A cleat or bracket of the type referred to, in accordance with the invention, is composed of a length of metal bar or rod of uniform section which is bent to form a cleat or bracket in one piece, whereby the whole of the metal is utilised and the waste consequent of stamping out the cleats (which is the hitherto usual

Fig. 1.

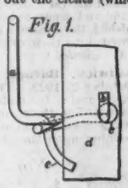
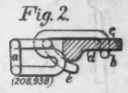


Fig. 2.



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method of manufacture) is avoided. The cleat illustrated has a bracket *a*, a hook *b* which is passed through a hole *c* in the flange of the bulb angle frame *d*, and a tail *e* which engages the front of the bulb angle frame and acts with the hook *b* to keep the cleat rigidly in position when the batten is in place in the bracket *a*. The shank of the hook *b* is bent around the tail *e* partly to embrace the same. It will be seen that the cleat is composed of a single length of bent rod or bar of uniform section throughout. (*Sealed.*)

STEAM ENGINES, BOILERS, EVAPORATORS, &c.

208,983. A. P. Quinn, Cardiff, and The Anchor Fir Bridge Company, Limited, Cardiff. Firebridges. (2 *Figs.*) May 22, 1923.—The invention relates to firebridges of the type in which the firebridge is formed with intersecting vertical and horizontal passages wherein the fire gases intermingle with air and combustion is promoted within the firebridge. According to the invention, air is conducted to the vertical passages of the perforated firebridge by a conduit formed by bridging the bottom of the furnace flue. *a* represents a boiler furnace flue and *b* the firegrate therein. *c* is a firebridge having horizontal passages *d* intersected by vertical passages *e*. The lowermost horizontal

Fig. 1.

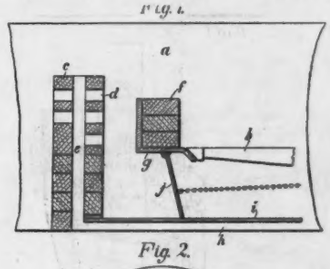
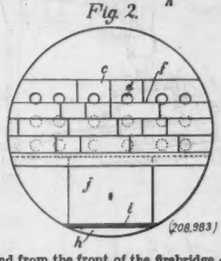


Fig. 2.



(208,983)

passages *d* extend from the front of the firebridge *c* only into the intersecting vertical passages *e*. The firebridge *c* is located a short distance in the rear of the firegrate *b* and extends upwards from the floor of the furnace flue *a*. An ordinary solid firebridge *f* extending to a less height than the firebridge *c* is mounted on the bearer *g* at the rear end of the firegrate *b*. Air is conducted from the front of the furnace to the bottoms of the vertical passages *e* by means of a conduit *h* formed by a plate *i* bridging a segment of the bottom of the furnace flue *a*. Air, however, is precluded from access from beneath the firegrate *b* to the unoccupied space between the two firebridges *c* and *f* by means of a door *j* hung on hinges beneath the bearer *g*. (*Sealed.*)

208,995. D. Rose, Lincoln. Full Way Valves. (6 *Figs.*) July 18, 1923.—The object of the invention is to provide means connected with a full way valve for allowing of the perfect regrinding or facing of the bearing surfaces of same. A valve disc A is fitted with a series of screwed pins B having rollers H

Fig. 1.

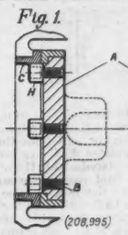
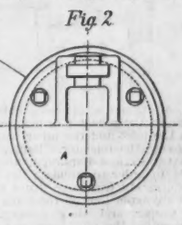


Fig. 2



(208,995)

on a part of their length, projecting therefrom on one side and so arranged that they can be changed over from one side of the disc A to the other when required for regrinding purposes. The screwed pins B are arranged in a circle and so placed that, in the normal working position of the valve, the rollers are on the outer side of the disc A as in Fig. 2 and form part of the structure of

the valve. When it becomes necessary to regrind or face up the surfaces, the valve is dismantled and the screws B and rollers H are withdrawn from the disc A and screwed into the opposite side (see Fig. 1). When this operation is completed, the rollers project beyond the disc face A and can be inserted into the valve ring seating C, as in Fig. 1. The disc is rotated by hand or other means to fulfil the regrinding operation. The rollers H being so placed, allow of easy rotation, maintain a perfectly concentric form and alignment and keep the disc A in a true position. Both the surfaces of the seat C and the valve disc A can then be ground up easily to a perfectly true and accurate bearing. When the regrinding operation is finished, the screwed pins B and rollers H are withdrawn and screwed into their original position on the reverse side of the disc A. (*Sealed.*)

209,155. V. R. Chadwick, Barnes, Surrey. Furnace Firebars. (5 *Figs.*) October 2, 1922.—The invention consists in the provision in furnace grates for boilers of firebars having a series of grooves or channels 5 in their top faces with a corresponding series of projections 8 on the adjacent firebar in juxtaposition with and encroaching upon the grooves or channels 5,

Fig. 1.

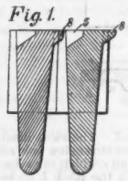


Fig. 2.

the grooves and/or the projections being of such angle and shape as will tend to prevent small fuels from falling between them unconsumed, and also to distribute the air over substantially the whole of the grate area. The firebars rest on bearers, spacing strips or distance strips being provided on the firebars so that when assembled air-spaces 4 will be formed between the firebars. (*Sealed.*)

208,948. P. W. Robson, Lincoln, and Clayton and Shuttleworth, Limited, Lincoln. Steam Generators. (3 *Figs*) February 23, 1923.—The invention relates to steam generators in which a superheater and steam reheater are provided. The invention broadly consists in a steam generator in which the drums of the steam reheater are situated immediately above, and supported upon, the water and steam drums of the generator itself and preferably arranged substantially at right angles thereto. Immediately above, and supported upon, the steam and water or separator drums *a*, *a*1 are the reheater drums *b*, *b*1, which are preferably placed substantially at right angles to

Fig. 1.

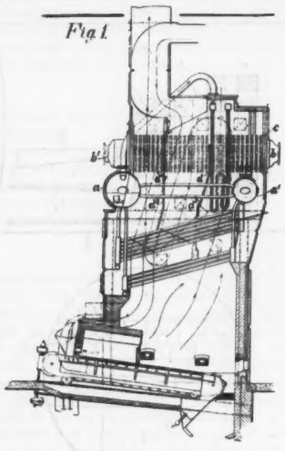
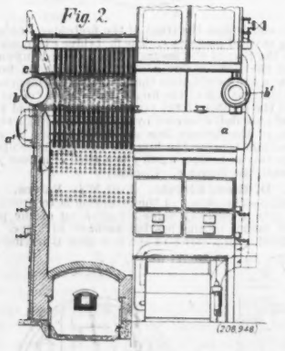
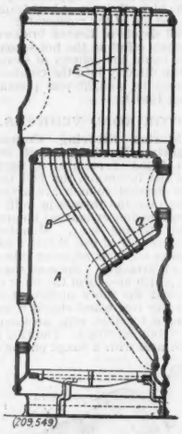


Fig. 2.



the drums, *a*, *a*1, and at opposite ends thereof. A number of tubes *c* connect the reheater drums, one of the latter being provided with the inlet and the other with the outlet for the fluid passing through the reheater. Baffle plates *d*, *d*1 are arranged between the tubes *c*, and diaphragms are placed within the reheater drums *b*, *b*1 in order to circulate the fluid passing through the reheater alternately from one drum to the other. The baffle plates *d*, *d*1 are extensions of the main baffles *d*2, *d*3 of the steam generator proper and they co-operate therewith and the diaphragms within the reheater drums *b*, *b*1 in such manner that the transfer of heat from the flue gases to the fluid in the reheater is on the contra-flow principle. (*Sealed.*)

209,549. Hartley & Sugden, Limited, Halifax, S. Fox, Halifax, and H. Waterworth, Halifax. Steam Generators. (4 *Figs.*) November 18, 1922.—The invention relates to a steam generator of the vertical type in which a group of inclined tubes B is fixed at the lower end in an inclined plate *a*, which projects inwards within the fire-box A, and at the upper end in the top of the fire-box, and the invention consists



in combining therewith a group of vertical fire or smoke tubes E extending through the water and steam space above the fire-box to one side of the group of inclined tubes.—(*Sealed.*)

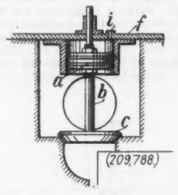
209,782. W. A. White, Jesmond, Newcastle-on-Tyne. Liquid Fuel Furnaces. (5 *Figs.*). September 13, 1922.—The object of the invention is to provide a device which is particularly adapted for the ignition of the liquid fuel spray in liquid fuel furnaces. In an ignition device, according to the invention, the resistance element consists of an insulating member *c* on which a coiled bare resistance wire *d*, anchored at *d*1 on the outer end of the member *c*, is wound as a double helix. The resistance wire

Fig. 1.

Fig. 2.

d is of a gauge and melting point which render it capable of withstanding a heavy current and is protected, together with the resistance terminals, by a perforated tubular housing *h*, which leaves an annular space around the resistance element, and is made of a metal having a higher melting point than the firing point of the fuel oil to be ignited, the housing being rendered incandescent on the passage of the current through the resistance. (*Accepted January* 30, 1924.)

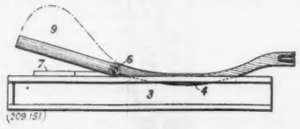
209,788. H. Bentley, Bolton. Steam Engines. (5 *Figs.*) September 19, 1922.—The invention relates to the valves of steam engines. A balance piston *a* is fixed to the spindle *b* of the steam inlet valve *e* and works in a balancing cylinder fixed to the outer wall *f* of the steam chest, the inner end of the cylinder being open thereto and the outer end being open to the atmosphere or connected by a passage *i* to the condenser. The steam pressure within the steam chest acting upon the upper or



steam-chest side of the poppet valve *e* and the under or steam-chest side of the balancing piston *a* equally, or in any desired ratio according to the area of the balance piston in relation to the area of the valve, enables the valve to be closed solely by the action of the usual spring and dash pot, and opened by a cam or other device through the agency of the valve gear, none of which details form any part of the invention. (*Accepted January* 30, 1924.)

TEXTILE MACHINERY.

209,151. J. Nelson, Nelson. Shuttle Box Swells (2 *Figs.*) October 2, 1922.—The improvements relate to the swells employed in shuttle boxes of that type which are pivoted at one extremity to allow them to give to the pressure of the shuttle as it enters the shuttle box. According to the invention, a shuttle box swell



is provided, on the other side of the pivotal centre on which the swell hinges, with a counter-weight. 3 is the shuttle box, and 4 the shuttle swell. The swell 4 is mounted upon the pivot 6 and has attached thereto the counterweight 9. (*Accepted January* 16, 1924.)

208,570. A. Cass, Swinton, J. Edden, Swinton, and T. Tuttiett, Lower Broughton. Shuttles. (4 *Figs.*) April 30, 1922.—The improvements relate to shuttles as used in weaving looms. 5 is a recess formed within the body of the shuttle case 6. 7 is a pin secured at either side of the recess 5. 8 is a metal member forming an adjusting device, which adjusting member is of the form shown in Fig. 1, that is, it is provided with a beak portion extending backwards. The adjusting member 8 is secured within the recess 5 by pins 9 which pass through holes in the shuttle case and holes formed in the member 8. As shown in Figs. 3 and 4, the beak portion of the adjusting member is bevelled off to zero in plan. 10, 10*a* are two limbs of metal forming the shuttle tongue, and brazed together at their outer ends, their other ends being bored and fitting pivotally within the recess 5 upon the pivot pin 7. As will be seen on a reference to Fig. 3, one of these limbs 10*a* is curved, whilst the other is straight or substantially so. The recess 5 is formed with inwardly and upwardly tapering walls as shown at 14 in

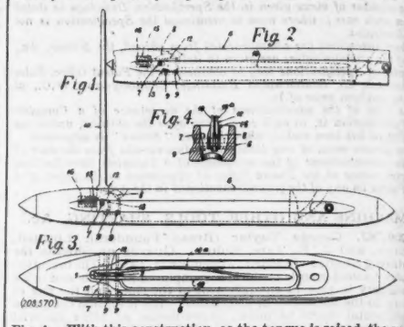


Fig. 4. With this construction, as the tongue is raised, the ends 12 of the limbs 10 and 10*a* are pressed together positively at the point where the beak of the adjusting member 8 allows such approach of the ends 12 to each other. To maintain the tongue in the lowered position, or in the raised position of Fig. 1, a recess opening into the recess 5 is provided. A metal plug 15 slides in this recess against the compression of a helical spring 16. Pressure of the plug 15 against the lateral edges of the portions 12 of the limbs 10 and 10*a* as shown in Fig. 1, or against the lower edges of these portions as shown in Fig. 2, will effectively retain the complete tongue in the raised or lowered position. (*Sealed.*)

208,858. J. L. Rushton, Bolton. Combing Machines. (2 *Figs.*) November 3, 1922. The invention relates to rotary brushes for combing machines, and the object of the invention is to construct a brush in such manner that it may be readily removed from the shaft without interference therewith when it is desired to renew it or for other purposes. For this purpose, the stock of the brush is formed wholly of metal and hollow with solid ends 3,

Fig. 1

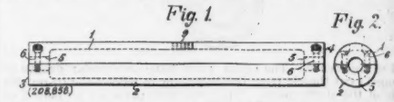
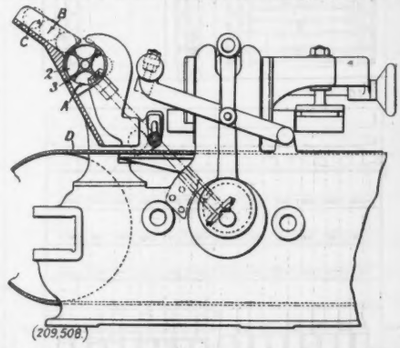


Fig. 2.

4 perforated at 5 to receive the shaft and the stock is longitudinally divided, the two parts 1, 2 thereof being connected together by means of set screws 6 preferably arranged at the ends, the screws passing through one part and screwing into tapped holes in the other part. The stock is provided with holes 9 through which the bristles are passed and sewn upon the interior of the stock by means of wire or the like. (*Sealed.*)

MISCELLANEOUS.

209,508. J. Gallimore, Rutherglen. Biscuit-Making Machinery. (2 *Figs.*) October 17, 1922.—The invention refers to biscuit-making machinery, and comprises apparatus for feeding or delivering separate bodies of dough in succession automatically. Machinery, according to the invention, comprises a feeding device A, in cross section of cylindrical character, rotating about its axis and arranged with its axis horizontal. In the feeding device pockets 2 are formed, arranged in circumferential alignment at, say, equal angles apart, which pockets extend inwards from the cylindrical surface and are separated circumferentially by peripheral surface portions 3 of the device. For dealing with, say, approximately spherical bodies of dough C, the pockets may be of semi-spherical form, greater or less to a small extent. Associated with a feeding device of this character, means are provided for directing the bodies C towards the device in a direction angularly downwards to the upper side of the device. For example, a chute B is provided, arranged with its surface directed angularly downwards to the periphery of the



feeding device at, say, 60 deg. more or less, so that bodies of dough C placed on the chute will tend to slide down by gravity and in one position, in the process of rotation of the device, the column of bodies will be sustained by a peripheral surface portion 3 of the device projecting above the surface of the chute, and in the process of rotation a pocket 2 will be brought into position to receive the lowest body and that body will be carried by the feeding device, passing over, and be discharged when the pocket has reached a position which no longer affords support to the body. Thus, pockets and peripheral surface portions of the feeding device are presented alternately to the lower end of the column composed of bodies of dough. In biscuit-making machinery, according to the invention, in which bodies of dough are required to be delivered to, say, a travelling band D advanced intermittently, on to which separate bodies are required to be deposited in succession, the drive applied to the feeding device may be intermittent or continuous and synchronise with, say, the main drive or the step-by-step drive of the travelling conveyor. (*Sealed.*)

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